SF/AR 2.2.2

NORTH RIDGE ESTATES - RI/FS WORK PLAN

U.S. ENVIRONMENTAL PROTECTION AGENCY

JULY 2006

North Ridge Estates - RI/FS Work Plan

Prepared for

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ACRONYMS

ACBM	asbestos containing building material
ACM	asbestos containing material
AOC	Administrative Order on Consent
ARAR	applicable or relevant and appropriate requirements
ATSDR	Agency for Toxic Substance and Disease Registry
bgs	below ground surface
BOM	bills of materials
CAB	cement asbestos board
CERCLA Act	Comprehensive Environmental Response Compensation and Liability
CFR	Code of Federal Regulations
COC	contaminant of concern
COPCs	contaminants of potential concern
DEQ	Oregon Department of Environmental Quality
DDD	dichlorodiphenyldichloroethane
DDE	dichlorodiphenyldichloroethylene
DDT	dichlorodiphenyltrichloroethane
DHS	Oregon Department of Human Services
DOD	United States Department of Defense
DQO	data quality objective
E&E	Ecology & Environment, Inc.
EPA	United States Environmental Protection Agency
FS	feasibility study
FSP	field sampling plan
ft^2	square feet
FUDS	formerly used defense site
g/cm^2	grams per square centimeter
gpm	gallons per minute
GSA	General Services Administration
HASP	health and safety plan
IARC	International Agency for Research on Cancer
IC	institutional controls
IRIS	Integrated Risk Information System
ISO	International Organization of Standards
lbs	pounds

ACRONYMS (CONTINUED)

MAO	Mutual Agreement Order
MBK	Melvin Bercot Kenneth Partnership
MBTA	Migratory Bird Treaty Act
MILCON	military construction
mm/year	millimeters per year
mg/kg	milligrams per kilogram
MRB	Marine Recuperation Barracks
Navy	United States Navy
NBEC	nitrate base explosive compounds
NCP	National Contingency Plan
NESHAP	National Emission Standards for Hazardous Air Pollutants
NHPA	National Historic Preservation Act
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NRE	North Ridge Estates
OAR	Oregon Administrative Rules
OCS	Oregon Climate Society
OERR	Office of Emergency and Remedial Response
ORNHIC	Oregon Natural Heritage Information Center
ORS	Oregon Revised Statutes
OSC	on-scene coordinator
OSHA	Occupational Safety and Health Administration
OSWER	Office of Solid Waste and Emergency Response
OTI	Oregon Technical Institute
OWRD	Oregon Water Resources Department
PAHs	Polynuclear aromatic hydrocarbons
PCBs	polychlorinated biphenyls
PCME	phase contrast microscopy equivalent
PEL	permissible exposure limit
PHC	Public Health Consultation
PLM	Polarized light microscopy
PPE	personal protective equipment
ppm	parts per million
PRG	preliminary remediation goal

ACRONYMS (CONTINUED)

PX	post exchange
QAPP	Quality Assurance Project Plan
RACM	Regulated asbestos containing material
RAO	remedial action objective
RBC	risk-based concentration
RI	remedial investigation
ROD	Record of Decision
RP	responsible party
S/cc	structures per cubic centimeter
S/g	structures per gram
SAP	sampling and analysis plan
SARA	Superfund Amendments and Reauthorization Act of 1986
SHINE	Superfund Health Investigation and Education Program
SSL	soil screening level
START	Superfund Technical Assistance and Response Team
SVOC	semi-volatile organic compound
TBC	to be considered
TCE	trichloroethylene
TEM	transmission electron microscopy
TPH	total petroleum hydrocarbons
TSI	thermal system insulation
UAO	Unilateral Administrative Order
UCL	upper confidence limit
USACE	United States Army Corps of Engineers
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geologic Survey
VAT	vinyl asbestos tile
VOC	volatile organic compounds
WAA	War Assets Administration
WWII	World War II
XRF	x-ray fluorescence

ACRONYMS (CONTINUED)

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EXECUTIVE SUMMARY

This document is a work plan for a Remedial Investigation/Feasibility Study (RI/FS) at the North Ridge Estates (NRE) site, located approximately 3 miles north of the City of Klamath Falls in south-central Oregon. This work plan outlines the RI/FS activities that will be conducted by US Environmental Protection Agency (EPA) at the NRE site. The RI will characterize the nature and extent of environmental contamination and estimate potential human health and ecological risks at the site. The FS will evaluate potential remedial actions to address any unacceptable risks.

Currently a residential development, the NRE site was formerly the Klamath Falls Marine Recuperation Barracks (MRB) facility, built to house recuperating veterans returned from the South Pacific after World War II (WWII). With over 80 buildings, the facility was constructed in 1944 and operated until 1946. The site was later used by the Oregon Technical Institute (OTI), and then transferred into private ownership in 1966.

From 1966 through the mid 1970s, some of the site buildings were demolished and materials such as copper and wood were salvaged. A private developer purchased the property in 1977 and demolished the majority of the remaining buildings. The developer subdivided the property into residential lots, and construction of homes in the subdivision began in 1993.

The process of demolishing the barracks buildings left debris which contained asbestos on the site. This asbestos containing material (ACM) included cement asbestos board (CAB) siding, roofing, floor tiles and pipe insulation. Much of the ACM was buried in shallow burial areas or spread across the site. It is also possible that non-ACM contaminants of potential concern (COPCs) associated with previous site operations may have been released at the site.

In July 2001, the Oregon Department of Environmental Quality (DEQ) responded to a complaint about exposed asbestos pipe insulation in the NRE development. DEQ visited the site and observed two large piles of pipe that contained insulation on the surface of the ground. In addition, white to pale brown-colored platy-looking rock fragments (presumably CAB) were observed on the ground of the property and surrounding properties. Samples were taken that showed the sampled material contained asbestos at levels of 10 to 90 percent.

The Oregon Department of Human Services (DHS) determined in 2003 that the NRE site was a past and present public health hazard due to the known health risks from exposure to friable (brittle or crumbling) asbestos. A variety of state and EPA regulatory and enforcement actions have been undertaken at the site to address the potential exposure of residents to asbestos. These actions include removal of surficial ACM, reconnaissance and stabilization of burial areas, air and soil sampling to assess the potential health risks, and temporary relocation of some residents during the summer of 2005. A recent legal settlement with the developer will result in most of the residents permanently leaving the site in mid-2006; however, a few residents have chosen to remain.

Despite the actions-to-date, ACM continues to appear at the surface in many places at the site. This reappearance is presumably due to a combination of surface erosion, frost heave, and freeze-thaw cycles. Once at the surface, the ACM can break down and release asbestos fibers to surface soil and air. The breakdown of ACM and release of asbestos fibers can be an ongoing source of exposure to residents in the area. Exposure to asbestos can increase the risk of both cancer and non-cancer diseases.

In addition to the use of ACM, historic uses at the site included activities that may have been associated with the release of hazardous substances other than asbestos. These substances may also present a potential risk to human health or the environment.

The focus of the RI/FS activities for the NRE site in general will be to assess potential human health and ecological risks presented by the contamination at the site, and to determine appropriate remedial actions that should be taken to address those risks. A considerable amount of investigation has already been completed to locate ACM at the site. The remaining work to complete the RI/FS will focus on resolving several key issues and performing the assessment of remedial actions potentially required. The remaining RI/FS issues to be evaluated include the following four items:

1. The reappearance of friable ACM at the surface is expected to continue. Because screening level calculations indicate that it is not practical to delineate unacceptable levels of ACM in subsurface soil, it will be assumed that all areas of the site that have had visible ACM on the surface or are in the vicinity of former base buildings contain potentially unacceptable levels of ACM. Those areas characterized as having ACM will be considered to present unacceptable potential future health risks and will be evaluated for remedial action.

2. There is a potential risk to current residents from exposure to asbestos fibers that have already been released to surface soils and may be present in the residents' homes. These risks can be presented by exposure to indoor air and dust or by outdoor activities that could disturb soils containing the fibers. The potential for current health risk to residents who remain at the site will be evaluated.

3. There are several relatively large land units where large quantities of ACM are known or suspected to have been disposed. In several cases non-ACM contaminants of potential concern (COPCs) may also be present in those units. For purposes of FS analysis, the presence, condition, and approximate quantity of the material in these land units will be determined. The large land unit analysis will allow for evaluation of potential remedial alternatives.

4. Various historical human activities at the site have been known, at similar sites, to result in the release of hazardous substances into media such as soil, including activities associated with operation of the barracks facility and university and with demolition of buildings associated with those operations. It is possible that these hazardous substances are present at concentrations exceeding health-based criteria. However, except in a limited number of cases, the presence of these substances at the site has not been determined. The presence of hazardous substances other than asbestos will be evaluated in the RI/FS. If these substances are present above levels of concern, remedial actions will be evaluated.

The RI/FS will follow the general steps outlined in federal and state laws and regulations. These steps include scoping of the RI/FS, conducting the RI, assessment of risks through a baseline risk assessment, and identification and evaluation of remedial alternatives through a FS. The process of identifying and assessing potential remedial actions will occur concurrently with the RI, with the final assessment summarized in the FS. Community involvement activities will be performed throughout the process. The RI/FS will be performed over an approximately 1.5-year period.

Following completion of the RI/FS, EPA will prepare a Proposed Plan which identifies the preferred remedial action. This Proposed Plan will include summaries of cleanup alternatives evaluated for use at this site and the rationale for selecting a preferred alternative. The Plan will be released to the public for review and comment. After public comments are reviewed and considered, EPA, with input from the State of Oregon, will select a final remedy. The final remedy decision will be documented in a Record of Decision (ROD) for the site.

1. WORK PLAN PURPOSE AND ORGANIZATION

1.1 PURPOSE OF THE WORK PLAN

This document is a Remedial Investigation/Feasibility Study (RI/FS) Work Plan for the North Ridge Estates (NRE) site. It outlines the RI/FS activities that will be conducted by US Environmental Protection Agency (EPA) to characterize the nature and extent of environmental contamination and the level of potential human health and ecological risks at the site and to evaluate potential remedial options to address these risks. EPA will work in close consultation with Oregon Department of Environmental Quality (DEQ), Oregon Department of Human Services (DHS), and other agencies to address issues at the site.

The NRE site is located approximately 3 miles north of the City of Klamath Falls in south-central Oregon. Currently a residential development, the site was formerly the Klamath Falls Marine Recuperation Barracks (MRB) facility. The Marine facility was constructed in 1944, operated until approximately 1946, and had over 80 buildings to house recuperating World War II (WWII) veterans returned from the South Pacific. Site ownership was later transferred to the State of Oregon and used by the Oregon Technical Institute (OTI) until the early 1960s. The site was then transferred into private ownership in 1966.

From 1966 through the mid 1970s, some of the site buildings were demolished and materials such as copper and wood were salvaged. A private developer (Melvin Bercot Kenneth Partnership [MBK] of Klamath Falls, Oregon) purchased the property in 1977. The majority of the remaining buildings were demolished in the late 1970s and 1980s. MBK subdivided the property into residential lots, and construction of homes in the subdivision began in 1993.

The process of demolishing the barracks buildings left building debris which contained asbestos at the site. This asbestos containing material (ACM) included cement asbestos board (CAB) siding, roofing, floor tiles and pipe insulation. Much of the ACM was buried in shallow burial areas, mixed with soil and scattered across much of the site, or disposed of in larger burial mounds, pits, or structures. The ACM became friable (brittle or crumbling) as a result of the demolition process and physical weathering. It is also possible that non-ACM contaminants of potential concern (COPCs) associated with the previous site operations may be present. The RI/FS will evaluate the potential risks and required actions to mitigate the risks associated with ACM and other COPCs at the site.

1.2 ADMINISTRATIVE AND REGULATORY REQUIREMENTS

The presence of asbestos in surface and subsurface soil at the NRE site is the result of demolition practices that included burying asbestos containing building materials (ACBM) on-site and hauling ACBM to adjacent locations for disposal. ACM has since surfaced on residential properties at NRE, resulting in potential exposures to residents, including children.

Despite prior investigations at the site by the Oregon DEQ, DHS and EPA and removal actions taken by MBK and EPA (more fully described in Section 3), residents remain potentially exposed to asbestos, creating potentially unacceptable health risks. DHS completed a Public Health Consultation (PHC) in 2003 which concluded that, due to the known health risks from exposure to friable asbestos and the volume and extent of friable ACM fragments on the site at that time and in the past, the asbestos present at NRE is considered to pose a past and present public health hazard.

EPA issued a Unilateral Administrative Order (UAO) for an RI/FS study to be completed by the individual partners of MBK in March 2005, pursuant to Section 106(a) of the

Comprehensive Environmental Response, Compensation, and Liability Act of 1980, 42 U.S.C. § 9606(a) as amended (Comprehensive Environmental Response Compensation and Liability Act [CERCLA]). The MBK partners subsequently submitted a Notice of Intent to Comply with the UAO. A draft RI/FS work plan was submitted to EPA in June 2005 by the MBK partners. EPA issued a Stop Work Notice for the RI/FS to MBK partners in July 2005 following a tentative settlement agreement between various litigating parties, including a group of NRE homeowners and MBK.

In January 2006, the U.S. District Court for Oregon approved and entered into a Consent Decree which represented the final settlement between MBK, homeowners, and the United States. Under the settlement, MBK was relieved of further responsibility for response actions at NRE, including conducting an RI/FS.

EPA is taking responsibility for conducting an RI/FS at the NRE site. No other potentially responsible parties capable of conducting the RI/FS have been identified at this time. The NRE site has not been proposed for inclusion on the Superfund National Priorities List (NPL). EPA is continuing to consult with the Agency for Toxic Substance and Disease Registry (ATSDR) and Oregon DEQ regarding eligibility of the NRE site for NPL listing.

The RI/FS will address potential risks at the site due to asbestos and non-asbestos COPCs associated with previous site operations. This work plan follows the general requirements for an RI/FS work plan prepared under CERCLA, as outlined in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (Office of Emergency and Remedial Response [OERR] 1988). The RI/FS will be conducted in a manner that is consistent with this guidance, EPA's data quality objectives (DQO) planning process (EPA 2000a), and other applicable guidance.

Following completion of the RI/FS, EPA will prepare a Proposed Plan which identifies the preferred cleanup alternative for contamination at the site. In addition, the Proposed Plan will include summaries of other cleanup alternatives evaluated for use at this site, and the rationale for selecting the preferred alternative. After public comments on the proposed plan and input from the State of Oregon are reviewed and considered, EPA will make a final cleanup remedy selection. This decision will be documented in a Record of Decision (ROD) for the site.

1.3 WORK PLAN ORGANIZATION

The Executive Summary and Sections 1 through 11 of this work plan are designed to provide a focused and logical discussion of the approach that will be taken to conduct the RI/FS at the site. The appendices provide supplemental and supporting information to the main body of the text.

The work plan is organized into the following areas:

- **Section 1, Work Plan Purpose and Organization**, describes the purpose and organization of the work plan.
- **Section 2, Background**, provides information about the history and use of the site, as well as conditions that are relevant to the technical assessment of the site.
- **Section 3, Regulatory Actions and Site Investigations**, summarizes the assessments and cleanup actions that have already been conducted at the site.
- **Section 4, Summary of Findings**, summarizes the key findings from previous investigations, provides a conceptual model for the release of contaminants and

routes of exposure at the site, and synthesizes the information to a specific set of issues that will be evaluated.

- **Section 5, Basic Approach to the RI for Asbestos**, provides a rationale for classification of the site parcels based on historically observations of the presence or absence of ACM, demonstrates the rationale of preliminary classification, and establishes the actions that will be taken to complete classification to allow for the determination of appropriate remedial action for each parcels.
- **Section 6, RI Investigation at Occupied Parcels**, outlines the approach to evaluate health risk to residents who will continue to live at the site after the court-approved settlement.
- **Section 7, Large Land Unit Characterization**, describes how large disposal areas potentially containing relatively large quantities of ACM and other COPCs have been identified and will be characterized for additional assessment.
- **Section 8, Non-ACM COPC Investigation**, summarizes how the location of non ACM-COPCs have been identified and will be evaluated.
- **Section 9, Remedial Investigation Tasks**, summarizes how the RI will be organized and conducted, how the RI Report will be prepared, and the approximate schedule for the RI activities.
- **Section 10, Feasibility Study Tasks**, describes how remedial action objectives (RAO) and remedial actions will be determined and how the FS report will be prepared.
- **Section 11, Schedule**, summarizes the overall RI/FS project schedule and provides general and specific milestones for key events and deliverables.
- **Section 12, References**, lists the major documents cited in the body of this work plan.
- **Appendix A, Calculation of Risk-Based Concentrations**, presents screening level equations and calculations that predict the level of human health risk associated with specified levels of asbestos in soil.
- **Appendix B, Borehole Calculations**, presents calculations of the number of boreholes required to detect ACM in subsurface soil.

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2. BACKGROUND

This section summarizes the site description, background, and physical setting at the NRE site.

2.1 SITE BACKGROUND

The North Ridge Estates (NRE) site is located approximately 3 miles north of the City of Klamath Falls, in Klamath County, Oregon, on Old Fort Road and North Ridge Drive (Figure 2-1). NRE is sited on the former location of an MRB and the OTI. While the City of Klamath Falls is at an elevation of 4,100 feet, NRE sits at an elevation of 4,800 feet. Peaks surrounding NRE are as high as 5,360 feet to the east and 5,460 feet to the west.

According to Klamath County tax lot records, land purchased for the NRE subdivision includes parcels in Sections 15 and 14, Township 38 South, Range 9 East, and covers approximately 422 acres. The NRE parcels in Section 15 comprise approximately 250 acres and include properties along Old Fort Road, Hunter's Ridge Drive, North Ridge Drive, and Thicket Court, as well as several parcels on Scott Valley Road. In addition, parcels in Section 14 (14-500, 14-600, 14-700, 14-800, 14-801, and 14-900), described as "North Ridge Estates 3rd Addition," comprise 172.44 acres of the NRE subdivision.

The developed area of the subdivision along Old Fort Road and North Ridge Drive currently includes 23 single-family homes, 8 undeveloped vacant lots, a warehouse, and a memorial park.

The main contaminant of concern (COC) at the NRE site is asbestos. Due to former demolition practices at the site, ACBM was buried and scattered throughout the site. The types of ACM that are present at the site include: CAB, vinyl asbestos tiles (VAT), floor tile mastic, roofing material, and insulation (AirCell and MAG) and tar paper used in steam piping. AirCell is a type of thermal system insulation (TSI); it consists of a corrugated asbestos paper product used as an outer coating for pipe insulation. The TSI material known as MAG, so called because the major asbestos content in the product is a magnesium silicate, was used to insulate high temperature utilities such as steam or condensate lines. Based on past operations and practices at the site, other potential COPCs include polychlorinated biphenyls (PCBs), lead and other metals, petroleum hydrocarbons, dry cleaning solvents, and other volatile and semi-volatile organic compounds (VOCs, SVOCs).

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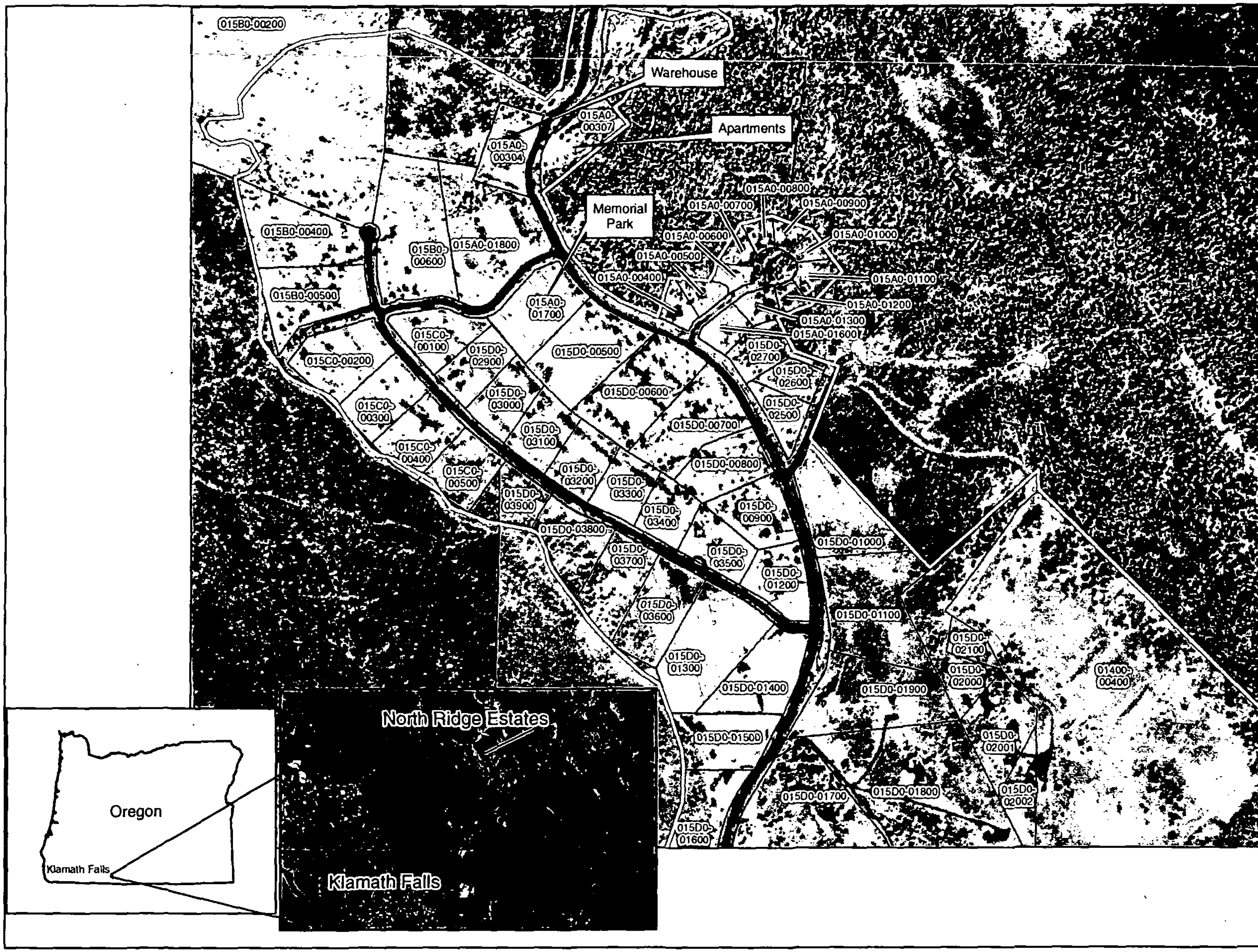

Figure 2-1
Site Location Map

Legend

Site Boundary
015B0-00200 Parcels
Developed
Undeveloped

N
0 0.05 0.1
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
1993 Aerial Photo

Contact Information:
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Portland, OR 97232-2131
(503) 233-2400

April 2006

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2.2 SITE HISTORY

2.2.1 Marine Recuperation Barracks (1944 to 1946)

The NRE site is the former location of the Klamath Falls MRB. The barracks were constructed by United States Department of Defense (DOD) to treat Marines suffering from tropical diseases contracted during WWII. The site was chosen as the location for the MRB because its elevation would act to moderate the effects of malaria. On June 24, 1944, the United States Navy (Navy) purchased approximately 745 acres of land, including nearly 11 acres for utility easements, near Klamath Falls, Oregon, from private parties for the MRB. Construction of the MRB was performed by a civilian general contractor and completed in accordance with standard plan books for the construction of posts, camps, and stations erected during WWII and immediately thereafter. Many of the plans were created by the US Army Corps of Engineers (USACE) and used by all US military departments. Military construction (MILCON) was standardized for ease in calculating bills of materials (BOMs), given that a specified population was to be served. The MRB facility was designed by the Lighthouse and Price architectural firm in Spokane, Washington. After authorization by the Department of the Navy, construction on the facility began on January 27, 1944 (Lynch 2005).

The facility was composed of 82 buildings designed to accommodate 5,000 Marines (Figure 2-2). Most of the buildings were constructed between Old Fort Road and present day North Ridge Drive. The structures built on the MRB site included a sewage treatment plant, horse stables, warehouse, brig, married officers quarters, animal hospital, dependent hospital, post exchange (PX), auditorium, gymnasium, swimming pool, fire house, mess hall, dispensary, laboratory, laundry, bakery, maintenance garage, bachelors quarters, central power plant, library, and 30 barracks.

The ACM used in construction of the barracks included CAB used on exterior walls as siding and on interior walls as "wainscoting," asphalt-asbestos roofing material, VAT, floor tile mastic, and steam pipe insulation. The amount of ACM used during the construction of the MRB has been estimated to be 1,522 tons. Table 2-1 shows the weight, per type of ACM, calculated to have been used in construction of the MRB (Kennedy/Jenks 2005).

Table 2-1. Summary of ACM Used in Construction of MRB, by Weight

Material Type	Weight (U.S. Tons)
Exterior CAB Siding	580
Interior CAB Panels	60
Roofing Material	150
Floor Tile	730
Steam Pipe Insulation	2
TOTAL	**1,522**

Personnel staffed the base by April 30, 1944, and the first contingent of Marine casualties arrived on May 27, 1944. The barracks officially closed on February 28, 1946. The entire 745 acres were declared surplus property by the Navy on March 1, 1946, and the land was transferred to the War Assets Administration (WAA) for distribution (Matthews 1992).

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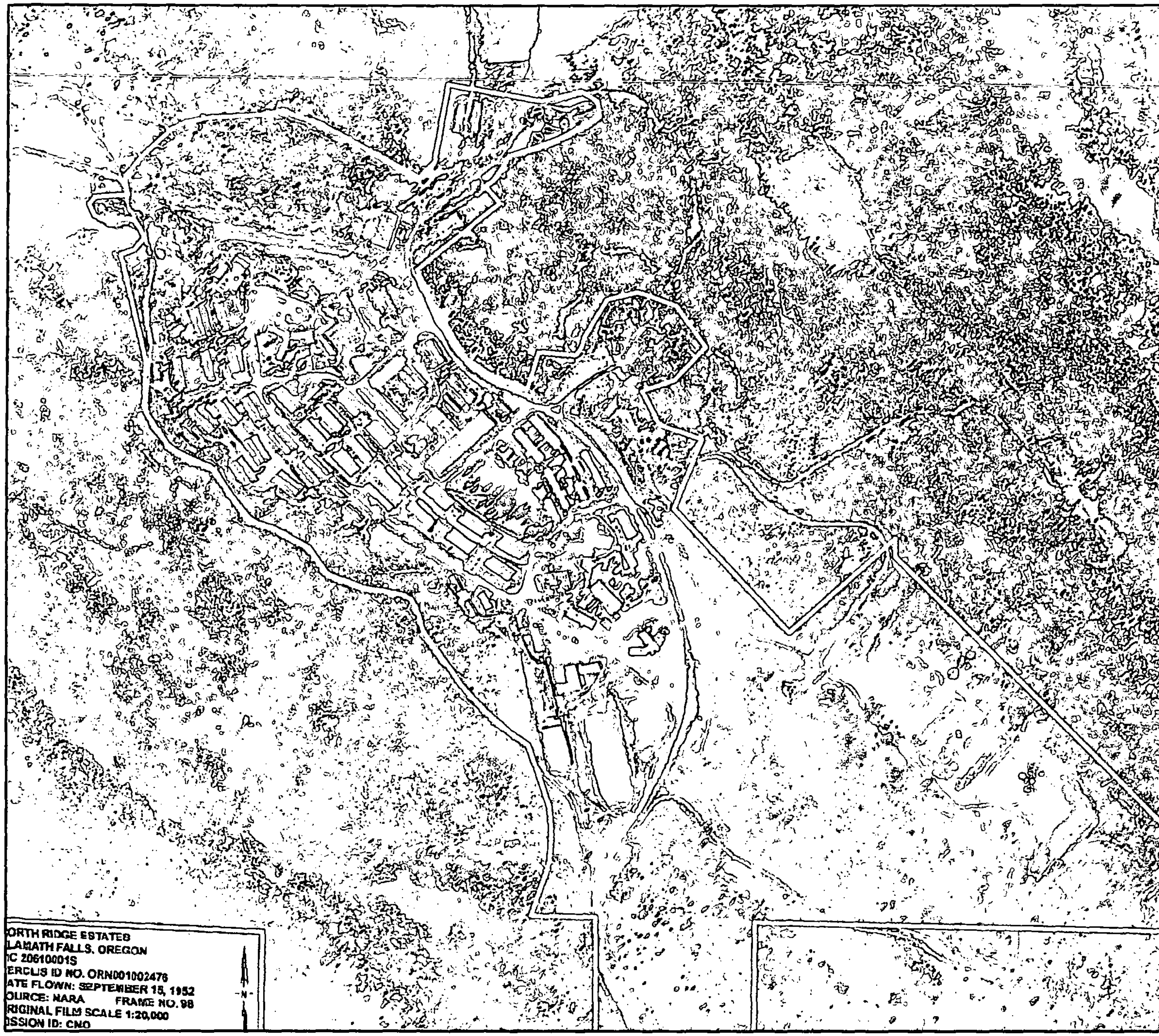

Figure 2-2
Marine Recuperation Barracks

Legend

Site Boundary

N

0 0.1 0.2
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

Contact Information:
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April 2006

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Parametrix

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2.2.2 Oregon Technology Institute (1947 to 1964)

The State of Oregon acquired the property through a Quit Claim Deed on October 28, 1947, to be utilized for OTI, now known as the Oregon Institute of Technology, where vocational courses were offered in the fall of that year (Matthews 1992). OTI offered courses in medical and x-ray technology; automobile, truck, and diesel engine maintenance; automobile body repair and painting; printing technology; metallurgy, welding, and machining; dry cleaning; and refrigeration service.

During OTI's occupancy of the site, six structures were demolished. These structures included the animal hospital, barrack building B-1, the fire hall's hose tower, gatehouse, dog kennel, and dependent hospital building. The dependent hospital was destroyed by snow load and removed. It is believed that material from the demolition of these structures was used by the OTI Superintendent of Facilities to repair and maintain other buildings onsite (Lynch 2005). In addition, two new buildings were constructed adjacent to the maintenance garage during OTI occupancy. OTI moved from the site in May 1964, having added seven new buildings and having acquired 40 additional acres of land.

2.2.3 General Service Administration (1964 to 1965)

Ownership of the site was transferred to the General Services Administration (GSA) in December 1964, when OTI left the property. An inspection conducted by GSA in July 1964 showed the site to be virtually intact; however, some buildings had fallen into disuse and were shuttered and boarded (Lynch 2005).

2.2.4 Private Ownership (1966 to 1977)

In 1966, a partnership of private individuals purchased the property from GSA. This private partnership owned the property until 1977. GSA reports that during this time, nothing was done to repair the buildings and signs of vandalism were noted. While this partnership owned the site, it is reported the owners stripped the vacant buildings of salvageable materials such as equipment, furnishings, copper, and wood. According to former site workers, asbestos insulation was stripped from piping and boilers; the stripped metal was sold, and the asbestos insulation remained at the site (Isom 2003). At least 22 buildings were demolished during the time this partnership owned the property.

2.2.5 MBK Ownership (1977 to Present)

In December 1977, the MBK partnership purchased the property. A former site worker has reported that at least 32 buildings were still standing at the site in 1978 (Isom 2003). Based on this statement and the 1979 aerial photograph, significant demolition occurred between 1978 and June 1979. Many of the site buildings were demolished before the June 1979 aerial photograph was taken. Buildings *not* demolished included the gymnasium, power house, warehouse, stables, brig, rifle range guard house, and the married officer's quarters on Thicket Court. Based on records from MBK, 34 buildings were removed between 1978 and 1991.

The former site worker who reported at least 32 buildings were standing in 1978 also reported that substantial amounts of building materials were burned, that remaining unburnable materials were buried on-site, and that the boiler and gymnasium building were demolished between 1992 and 1995 without the removal of ACM (Isom 2003).

In 1989, one member of the partnership left, and the remaining partners began planning for a subdivision. In 1993, Klamath County approved subdivision plans, and construction of homes in the subdivision began later that year. According to the PHC report published by the DHS Superfund Health Investigation and Education Program (SHINE), the present NRE subdivision developed by MBK encompasses 422 acres, although many of the lots have not been sold. Klamath County Public Health Division records related to test pits for septic system approval at the site occasionally noted the presence of asbestos debris in the soil. A test pit record dated June 27, 1996 for Township 38, Range 9, Section 15, Lot 6 indicated encountering "an old heat duct (cast iron pipe with asbestos & pipe sleeve around it)" at a depth of 0-6 inches below ground surface (bgs) (Kennedy/Jenks 2005).

MBK began selling properties in the subdivision in 1994, and continued to sell lots until 2002. As described in greater detail in Section 3.1, in 2001 DEQ received a complaint about exposed asbestos pipe insulation and observed ACM on the ground. In 2003 a group of subdivision homeowners sued the MBK partnership and the partners. In 2004, MBK declared bankruptcy. In June 2005, a settlement between the subdivision homeowners and MBK was announced, whereby MBK agreed to compensate the homeowners to allow them to relocate to new, permanent residences away from the site. In January 2006, the settlement was finalized in a consent decree that also appointed a receiver to hold title to the vacated property and search for a purchaser willing to implement final cleanup measures to be selected by EPA (U.S. Department of Justice press release, January 23, 2006). The settling homeowners are to have relocated by June 1, 2006. It is expected that four homes at NRE will remain occupied after the remaining homes are vacated under the settlement.

2.3 PHYSICAL SETTING

NRE is located in the southwestern portion of the Klamath Basin. The Klamath Basin lies in a transitional zone between the Cascade Mountains and the Basin and Range provinces, specifically, the Great Basin and East Cascade physiographic provinces. These provinces are dramatically different in climate, geology, and ecology, and both play an important role in the physical setting of the site.

2.3.1 Surface Features

The MRB buildings remaining today include a warehouse, the former brig (renovated into a five-unit apartment building), and several residences on Thicket Court used as officers' quarters during the time the military used the property and as facility housing during OTI occupation. A guard shack for the military base shooting range also remains standing east of the subdivision, but is being investigated separately by the USACE as a Formerly Used Defense Site (FUDS) (Ecology & Environment [E&E] 2005).

Although the other former military base structures at the site have been demolished, the concrete foundations for many of the buildings remain intact. Some of the old roads from the base are also still visible, although they are cracked and vegetation is growing through them. At the site, Old Fort Road and North Ridge Drive appear to follow approximately the same route they did when the base was operating (DHS 2004).

2.3.2 Meteorology

Prevailing air masses move across Klamath County from the Pacific Ocean, but are greatly modified as they move over the Coast Range and Cascade Mountains. Continental air masses that move down from the interior of western Canada are also a major weather factor. The resulting climate in Klamath County is much drier than that of western Oregon, which has more variable but generally warmer temperatures than Klamath County, particularly in winter months (Natural Resources Conservation Service [NRCS] 1985).

Winter rainfall in the area is characterized by a secondary peak in May, just prior to the dry summers. Seasonal characteristics are well defined, and changes between seasons are generally gradual. Average annual precipitation ranges from 10 to 15 inches in the valleys, 16 to 25 inches in nearby hills, and 30 to 40 inches at the lower levels in the Cascades to the west. About 44 percent of the moisture in the area occurs in winter, 22 percent in spring, 8 percent in summer, and 26 percent in fall. Wet days with at least 0.10 inch of moisture vary from 43 days annually in the valleys to 105 days in the mountains (NRCS 1985).

Snowfall accounts for 30 percent of the moisture in the valleys and as much as 50 percent of the moisture in the mountains. Annual snowfall averages 15 to 45 inches in the valleys, 60 to 125 inches in the foothills, and over 160 inches in some places at more than 4,500 feet. Maximum snow depths have varied from 2 to 3 feet in the valleys and from 5 to 6 feet in the hills and mountains (NRCS 1985).

At Klamath Falls prevailing winds are southerly for November through February; westerly from March through July; and northerly during August, September, and October. Monthly speeds average from 4.4 miles per hour in September to 7.3 miles per hour in March. Wind conditions are calm 17 to 33 percent of the time. Early morning values of relative humidity average 74 to 83 percent year-round, and the afternoon low values range from 26 to 33 percent in the summer to 62 to 74 percent in the winter (NRCS 1985).

The site is located in the largest of Oregon's climatic divisions, South Central Oregon, known to the Oregon Climate Society (OCS) as climate zone 7. This climate zone is characterized by a vast area of high desert prairie punctuated by a number of mountain ranges and isolated peaks. Most of this region receives relatively low amounts of precipitation. Most areas in this climate zone receive their highest monthly precipitation in the winter months, with a secondary maximum during late spring or early summer. Klamath Falls has received an average of 13.95 inches of precipitation annually from 1971 to 2000, with most precipitation falling in January and December. The driest months in Klamath Falls have historically been July, August, and September (OCS 2005).

2.3.3 Surface Water Hydrology

The site is located within the Upper Klamath Lake subbasin of the Upper Klamath Basin. Klamath Lake, the largest freshwater lake in Oregon and one of the largest in the United States, is located in the Upper Klamath Lake watershed. The Upper Klamath Basin covers 5.6 million acres, with the Upper Klamath Lake subbasin comprising nearly 500,000 acres.

In the arid to semi-arid locations of Klamath County, most precipitation-replenished soil moisture evaporates or is transpired by vegetation. Little is left to maintain stream flow or recharge aquifers. Precipitation that falls as snow generally does not become runoff until spring thaws begin (United States Geologic Survey [USGS] 1999b).

The occurrence of surface water at the site is limited to an intermittent stream that flows north from the site, roughly following Old Fort Road. The stream ultimately terminates at a canal for Upper Klamath Lake that is used to irrigate lands in the Lost River Basin of Oregon and California.

2.3.4 Geology

The location of the site, in an area of transition between the Cascade Mountains and the Basin and Range provinces, results in complex geology. The Klamath Basin is primarily composed of volcanic deposits with lowland fluviolacustrian deposits that have been described as consolidated volcanic rocks consisting largely of lava; unconsolidated to semi-consolidated volcanic ejecta deposited around eruptive centers; and lowland fluviolacustrian deposits consisting of dolomite, water-lain volcanic sediment, tephra, and lava (USGS 1999b).

The Klamath Basin is in part a composite graben formed by north and northwest trending normal faults. Vertical displacements are generally less than 330 feet, but locally exceed 1,000 feet (USGS 1999b). The Klamath graben fault system confines the Klamath Lake Basin at the intersection of the northwestern Basin and Range and Cascade Mountains in southern Oregon. The slip rate along this fault system is between 0.2 and 1.0 millimeters per year (mm/year). The Klamath graben fault system is divided into three sections: the West Klamath Lake section, the East Klamath Lake section, and the South Klamath Lake section. Faults in the South Klamath Lake section form composite grabens in the vicinity of Klamath Falls. To the north, large escarpments on Miocene and Pliocene bedrock define a graben that confines Upper Klamath Lake; fault scarps are formed on Holocene and Pleistocene talus deposits along these escarpments. The lack of extensive alluvial fans at the mouths of canyons that empty into Upper Klamath Lake may indicate late Quaternary subsidence along the margins of the Upper Klamath Basin. South of Klamath Falls, the graben system widens into a series of fault blocks and grabens (USGS 2002).

2.3.5 Soils

According to the NRCS soil survey of Klamath County (NRCS 1985), three main soil types are present at the site: Royst stony loam, 5 to 40 percent north slopes; Royst stony loam, 5 to 40 percent south slopes; and Woodcock association, north.

The majority of soil at the site is classified as Royst stony loam. All the area south of Old Fort Road and roughly north of Hunter's Ridge Road are described as Royst stony loam, 5 to 40 percent north slopes. The area north of Old Fort Road, including Thicket Court, is described at Royst stony loam, 5 to 40 percent south slopes. NRCS (1985) describes Royst stony loam as a well drained soil found on timbered escarpments. It is formed in very gravelly material weathered from tuff, basalt, andesite, and a small amount of pumiceous ash. Tuffaceous bedrock is found at a depth of 25 to 40 inches. This soil type is found at elevations ranging from 4,300 to 5,500 feet, and an average annual precipitation of 15 to 18 inches. In areas of Royst stony loam, the average annual air temperature is 43 to 45 degrees Fahrenheit (°F). Permeability in these soils is slow. Runoff is rapid following snowmelt in spring in unprotected or bare areas, and the hazard of erosion is high. Available water capacity is as low as 2.5 inches where depth to bedrock is 25 inches and the soil is extremely gravelly; it is as high as 6 inches where depth to bedrock is 40 inches and the soil is less gravely. The water-supplying capacity for natural vegetation is about 8 to 13 inches.

Soils directly to the north of Thicket Court and continuing north to Old Fort Road are classified by NRCS as belonging to the Woodcock association, north (NRCS 1985). These soils are well drained and found on escarpments of fault block mountains. They formed in extremely gravelly colluvium weathered from andesite, basalt, and a small amount of cinders and ash. These soils are underlain by bedrock at a depth of more than 60 inches. Slopes are concave and vary from 500 feet to more than 3,000 feet in length. The average slope is about 20 percent. This soil type is found at elevations ranging from 4,200 to 5,900 feet, and an average annual precipitation of 18 to 22 inches. In areas of Woodcock association soils, the average annual air temperature is 43 to 45 °F. Permeability in these soils is moderate. Runoff is medium, and the hazard of erosion is moderate. Available water capacity is 4 to 7 inches. The water-supplying capacity for natural vegetation is 11 to 16 inches (NRCS 1985).

2.3.6 Hydrogeology

The primary hydrogeologic units in Klamath County were described in 1958, 1970, and 1974, as: 1) a highly permeable lower (older) basalt unit which serves as the principal aquifer in the area; (2) the Yonna Formation (a medial zone of stratified lacustrine deposits consisting of tuff, agglomerate, shale, diatomite, sandstone, and volcanic ash with some volcanic intrusives or interbeds of thin lava flows) which primarily confines groundwater; and 3) upper, younger units (lava flow forming cap rock in place, eruptive deposits, and alluvium) which occur above the water table or yield small quantities of perched water (USGS 1999a).

The USGS has worked to improve the earlier descriptions of the aquifer system in Klamath County. The USGS classifies the aquifer system underlying much of Klamath County, including the area covered by the site, as a volcanic and sedimentary rock aquifer. Volcanic and sedimentary rock aquifers consist of a variety of volcanic and sedimentary rocks. The volcanic rocks that compose the aquifers consist primarily of Pliocene and younger basaltic rocks; unconsolidated volcanic deposits included in the aquifers are ash and cinders. The sedimentary rocks that compose the aquifers consist primarily of semi-consolidated sand and gravel eroded mostly from volcanic rocks. In some places, the aquifer might consist of a single rock type; in other places, the aquifers might consist of several interbedded rock types (USGS 1999b).

The permeability of the various rocks that compose the volcanic and sedimentary rock aquifers is extremely variable. Interflow zones and faults in basaltic lava flows; fractures in tuffaceous, welded silicic volcanic rocks; and interstices in coarse ash, sand, and gravel mostly yield less than 100 gallons per minute (gpm) of water to wells. Rarely, wells will yield several thousand gpm. Where major faults are present, the rocks commonly contain geothermal water under confined conditions (USGS 1999b).

The hydrogeologic characteristics of the volcanic and sedimentary rock aquifers are largely unknown. Also, the subsurface extent of these aquifers is largely unknown because of limited outcrop areas where they are shown overlaying older rocks or because they are too deep for many wells to reach economically. In Klamath and Lake Counties the volcanic and sedimentary rock aquifers are extremely permeable in places, and large quantities of water are withdrawn by wells for public supply, domestic, commercial, agricultural, and industrial purposes (USGS 1999a).

Basin and Range style faulting has divided the Klamath Basin into a series of small subbasins. It has been indicated that geologic structures generally impact groundwater flow locally rather than having basin-wide impacts, and that groundwater moves freely across fault zones in most areas. In addition it has been found that regional, intermediate, and local groundwater flow occurs within the Klamath Basin. Groundwater flow between subbasins has been speculated to occur, although supporting data is limited. Earlier work has identified uplands as the primary groundwater recharge areas for all the flow systems because of greater precipitation and permeability. Discharge occurs locally in mountain slope springs and nearby lowlands, and regionally at the lowest basin elevations, via upward seepage and springs (USGS 1999a).

Flowing artesian wells in the vicinity of Upper Klamath Lake and a large number of springs indicate that strong upward components of groundwater flow occur in many parts of the Klamath Basin. The groundwater discharge plays an important role in providing discharge to Upper Klamath Lake and base flow to streams in the basin (USGS 1999a).

A geothermal system within the Klamath Basin is indicated by the occurrence of hot springs and hundreds of warm water wells in the vicinity of the City of Klamath Falls and areas to the south near Olene Gap and Klamath Hills. Klamath Falls has developed geothermal water in the volcanic and sedimentary rock aquifers into a system for heating homes and public buildings. As many as 500 wells supply geothermal water and generally yield from 100 to 3,000 gpm. A conceptual model of the geothermal system was developed in which meteoric waters in a deep regional flow system circulate to depths of up to 10,000 feet by way of interconnected fracture zones. The waters are heated to 130°C before they move upward into the shallow groundwater system along basin and range faults. Most of the thermal discharge does not reach the surface, but moves outward from the fault conduits into permeable zones in basalts where it mixes with cooler, shallow groundwater. The relation of the thermal groundwater system to the shallow non-thermal system is not well understood (USGS 1999a).

A domestic supply well (Well ID L42727) was installed in August of 2000, approximately 0.8 miles north of the site at a residence on Old Fort Road. Groundwater was first encountered at 518 feet bgs during drilling and the static water level of this well is 378 feet bgs. The water bearing units in this well were described as gray clay with streaks of black sand (518 to 536 feet bgs), gray clay (536 to 571 feet bgs), cemented gravel (571 to 590 feet bgs), gray claystone (590 to 672 feet bgs), black sandstone (672 to 698 feet bgs), and gray claystone (698 to 843 feet bgs). Above the water bearing units materials were described as clays, sandstone, and claystone (Oregon Water Resources Department [OWRD] 2000).

2.3.7 Demography and Land Use

According to Klamath County tax lot records, land purchased for the NRE subdivision includes land in tax lots of Section 14 and 15, Township 38 South, Range 9 East, and covers approximately 422 acres. The tax lots in Section 15 comprise approximately 250 acres and include properties along Old Fort Road, Hunter's Ridge Drive, North Ridge Drive, and Thicket Court, as well as several parcels on Scott Valley Road. In addition, tax parcels in Section 14 (14-500, 14-600, 14-700, 14-800, 14-801, and 14-900) are described as "North Ridge Estates 3rd Addition." These lots comprise 172.44 acres of the NRE subdivision.

The developed area of the subdivision along Old Fort Road and North Ridge Drive currently includes 23 single-family homes, 8 undeveloped vacant lots, a warehouse, and a memorial park. DHS (2004) indicates that in 2002 there were 77 residents, including 35 children, in the developed area of the site. East of Old Fort Road are several homes, a five-unit apartment building (the former MRB brig), the Thicket Court residential homes, and additional vacant lots. According to the 2000 US Census, there are 98 residents within one-half mile of NRE. Land to the west, east, and north of the site is zoned for forestry, animal husbandry, and agriculture.

2.3.8 Ecology

2.3.8.1 Terrestrial Animals

According to range maps produced by the US Forest Service and Bureau of Land Management (United States Department of Agriculture [USDA] 2003), terrestrial species with ranges that include the area of NRE include numerous invertebrates, amphibians, reptiles, birds, and mammals.

Range maps were only available for a selected number of invertebrates. Invertebrates with ranges overlapping with the location of NRE include carpenter ant (*Camponotus modoc*), jumping spider (*Metaphidippus aeneolus*), thatch ant (*Formica obscuripes*), and Western yellow jacket (*Vespula pensylvanica*).

Amphibians with ranges overlapping the location of NRE include bullfrog (*Ranta catesbeiana*), Great Basin spadefoot (*Spea intermontana*), long-toed salamander (*Ambystoma macrodoctylum*), Pacific chorus frog (*Pseudacris regilla*), and Western toad (*Bufo boreas*).

Reptiles with ranges overlapping with the location of NRE include common garter snake (*Thamnophis sirtalis*), racer (*Coluber constrictor*), rubber boa (*Charina bottae*), sagebrush lizard (*Sceloporus gracious graciosus*), short-horned lizard (*Phrynosoma douglassii*), western rattlesnake (*Crotalus viridis*), western skink (*Eumeces skiltoniau*), gopher snake (*Pituophis catenifer*), striped whipsnake (*Masticophis taeniatus*), western fence lizard (*Sceloporus occidentalis*), western pond turtle (*Clemmys marmorata*), and western terrestrial garter snake (*Thamnophis elegans*).

The ranges of over 220 birds and 70 mammals overlap the portion of Klamath County where NRE is located.

2.3.8.2 Plants

The NRE site exhibits plant species that are dominant in the Great Basin shrub steep ecoregion. Dominant plant species of the shrub steep include cold-temperature species: sagebrushes (*Artemisia*), saltbushes (*Atriplex*), and winterfat (*Ceratoide*). These scrub species are much-branched, non-sprouting, aromatic semibrushes with soft wood and evergreen leaves. Species also tied to warmer climates are also found in the Great Basin shrub steep: rabbitbrush (*Chrysothamuns*), blackrush (*Coleogyne*), hopsage (*grayia*), and horsebrush (*Tetradymia*) (WWF 2001).

Because of the NRE site's location in an area of transition between the Great Basin and the Cascade Mountains, plant species at the site also include plants of the southern Cascade forests, such as scattered junipers and ponderosa pines.

2.3.8.3 Presence of Threatened and Endangered Species at NRE

According to the United States Fish and Wildlife Service, there are 41 threatened or endangered animal species and 15 threatened or endangered plant species in the state of Oregon. The Oregon Natural Heritage Information Center (ORNHIC) Institute for Natural Resource (ORNHIC 2004) has indicated that one of the endangered or threatened plants and ten of the endangered or threatened animal species are present in Klamath County:

Shortnose sucker (*Chasmistes brevirostris*)	Northern spotted owl (*Strix occidentalis caurina*)
Lost River sucker (*Deltistes luxatus*)	Gray wolf (*Canis lupus*)
Bull trout (*Salvelinus confluentus*) – Klamath River population	Canada lynx (*Lynx canadensis*)
Bull trout (*Salvelinus confluentus*) – Columbia River population	Grizzly bear (*Ursus arctos horribilis*)
Western snowy plover (*Charadrium alexandrinus nivosus*).	Applegate's milk-vetch (*Astragalus applegatei*)
Bald eagle (*Haliaeetus leucocephalus*)	

By comparing the above list with terrestrial range maps (USDA 2003), it would be expected that NRE is within the range of the western snowy plover, bald eagle, northern spotted owl, and the gray wolf. Because of the lack of surface water at NRE, it would be expected that none of the fish species listed above would occur at NRE. Although Klamath County is within the historical range of the Canada lynx and grizzly bear, it is highly unlikely that NRE would represent current habitat for these animals. According to the United States Forest Service, there have been 12 verified lynx sightings in Oregon since 1897, and DNA testing has confirmed the lynx in northern Oregon in 1999. According to the Oregon Department of Fish and Wildlife, the last grizzly bear in Oregon was sighted and shot in 1937. In addition, because Applegate's milk-vetch grows at an elevation of approximately 4,100 feet and does not grow in disturbed soil; it is unlikely this plant species is present at NRE.

3. REGULATORY ACTIONS AND SITE INVESTIGATIONS

3.1 HISTORY OF SITE REGULATORY ACTIVITIES

The Oregon DEQ responded to a complaint in 1978 of openly accumulated asbestos debris at the property owned and operated by MBK. ODEQ staff observed a bulldozer being driven over 4 to 6 acres of demolition debris and described "a great amount of white, fluffy insulation materials being blown by strong winds." ODEQ then directed the collection and on-site burial of some asbestos demolition material (DEQ 1978).

In September 1979, the EPA Region 10 issued Compliance Order No X79-08-14-113, regarding hazardous air pollutants, to MBK. The compliance order included findings that MBK engaged in demolition of structures that contained asbestos and worked in an area with asbestos debris causing release of asbestos. The asbestos release resulted from failing to remove ACM from buildings prior to their demolition as required by state and federal air quality regulations, and failing to contain ACM according to disposal practices in those regulations (EPA 1979). On October 4, 1979, Bercot, on behalf of MBK, indicated that they would comply with EPA's order.

On July 29, 2001, DEQ received a complaint about asbestos pipe insulation exposed to the atmosphere on North Ridge Drive in the NRE development. On July 31, 2001, DEQ visited the site and observed two large piles of pipe on the surface of the ground that contained insulation (180 linear feet). In addition, white to pale brown-colored platy looking rock fragments (presumably CAB) were observed on the ground of the property and surrounding properties. During this visit, samples were taken from the pipe insulation and the assumed CAB. Analysis of the samples showed that the material removed from the piping, described as white insulation from pipe, was 90% asbestos (amosite and chrysotile). Other material sampled from the pipe insulation contained 40 to 70% chrysotile. The sample of CAB contained 10% chrysotile. Tomahawk Abatement removed 180 feet of piping in August of 2001. DEQ issued a Notice of Noncompliance to MBK in September 2001 regarding the asbestos violations discovered during the July incident (DEQ 2001).

In June 2002, MBK entered into a Mutual Agreement Order (MAO) (Order No. AQ/AB-ER-01-250A) with DEQ, which required a survey of all properties, currently or previously owned by the MBK partnership, for the presence of ACM and required the removal of openly accumulated ACM. Additional requirements for MBK included either removing buried ACM or placing a deed restriction on properties known to have buried ACM, pursuant to the 1979 EPA compliance order. Approximately 50 tons of ACM were collected from the NRE site and disposed of by Malot Environmental, Inc., an MBK contractor, in 2002 (E&E 2005).

In March 2003, DEQ and DHS determined that the friable asbestos not removed from the site in 2002 continued to pose a significant public health hazard. DEQ then began negotiations with MBK to prepare an RI/FS to include a site characterization, human health risk assessment, and remedy identification. MBK and DEQ were unable to agree on the scope of the RI/FS. DEQ requested a referral to EPA on April 14, 2003, for emergency removal and assessment. On May 20, 2003, MBK entered into an Administrative Order on Consent (AOC) with EPA (EPA 2003). Investigation and removal activities carried out between 2003 and 2005 under the AOC are discussed in Section 3.3.

3.2 CONTAMINANTS OF CONCERN

3.2.1 Asbestos

Asbestos is the main COC at the NRE site. Asbestos is a generic name given to a fibrous habit of a variety of naturally occurring silicate minerals. Asbestiform minerals are divided into two major classifications, the amphibole group and serpentine group. Amphibole minerals are chained silicates which are straight and needle-like. Serpentine minerals are silicates with a lattice or spiral type structure. Table 3-1 identifies the six most common asbestos types used in commerce. Other types of natural occurring asbestos mineral forms have been identified that are not listed in Table 3-1.

Table 3-1. Most Common Asbestos Mineral Types Used in Commerce

Amphibole Group	Serpentine Group
Amosite	Chrysotile
Crocidolite	
Tremolite	
Anthophyllite	
Actinolite	

Asbestos was historically used in various building materials because it was relatively inexpensive, virtually indestructible, chemically resistant to acids, resistant to bacteria, non-combustible, noise absorbing, thermally insulating, electrically insulating, strong, and flexible.

Prior to the 1970s, asbestos was used in over 3,600 products. Approximately 66% of the materials that contain asbestiform minerals are asbestos-cement products and include flat sheets (CAB), siding, roofing sheets, rainwater pipes, gutters, and pressure piping. These products generally contain 10 to 15% asbestos fibers, which function as reinforcement in the cement mixture.

Chrysotile comprised approximately 93% of the total asbestiform mineral usage in the United States; the remaining 7% was typically amosite or crocidolite. Table 3-2 summarizes some of the known uses of each asbestos type.

Table 3-2. Asbestiform Mineral Uses

Mineral Name	Chemical Formula	Known Uses
Actinolite	$Ca_2(Mg,Fe)_5Si_8O_{22}(OH)_2$	cements, adhesives
Amosite	$(Mg,Fe)_7Si_8O_{22}(OH)_2$	filter aid in high pressure piping, preformed thermal insulation, pipes, slabs, and molded pipe fitting covers
Anthophyllite	$(Mg,Fe)_7Si_8O_{22}(OH)_2$	cements, adhesives
Chrysotile	$Mg_3Si_2O_5(OH)_4$	cement pressure pipe, asphalt flooring, vinyl floor tiles, paving, road surfaces, brake linings, clutch facings, gaskets, reinforced plastics
Crocidolite	$NaFe_3^{2+}Fe_2^{3+}\ Si_8O_{22}(OH)_2$	cement pressure pipe, preformed thermal insulation
Tremolite	$Ca_2Mg_5Si_8O_{22}(OH)_2$	cements, adhesives

The types of ACBM that have been found at NRE include CAB, VAT, floor tile mastic, roofing material, and insulation and tar paper used in steam piping.

Bulk samples of ACM found at NRE indicate that chrysotile and amosite are the two main types of asbestos present in ACBM at the site. Table 3-3 summarizes the asbestos concentrations observed in ACM at NRE (E&E 2006).

Table 3-3. Summary of Asbestos Content of ACM at NRE (E&E 2006)

Material Type	Asbestos Type	% Asbestos
CAB	Chrysotile	3 – 25
Roofing Material	Chrysotile	30 – 45
VAT	Chrysotile	<1 – 10
AirCell	Chrysotile	35 – 40
MAG Insulation	Chrysotile	3 – 25
	Amosite	20 – 55
Tar Paper	Chrysotile	35 – 40

The presence of asbestos at NRE is a significant human health concern because of the known link between asbestos inhalation exposure and certain types of cancer and other diseases, including lung cancer, mesothelioma, asbestosis, pleural plaques, pleural thickening, and pleural calcification. The ATSDR has based this conclusion on observations of these diseases in groups of workers with cumulative exposures ranging from about 5 to 1,200 fiber-year/ml (ATSDR 2003). The most serious of the asbestos-related diseases are discussed below.

Lung cancer is a malignant tumor that invades and obstructs the lung's air passages. The latency period for lung cancer caused by inhalation of asbestos is usually at least 15 years, with a peak at 20 to 30 years.

Mesothelioma is a rare cancer which may affect the lining of the lungs or the peritoneum. Mesothelioma has the longest latency period of the asbestos-related diseases. Thirty or more years can pass between exposures and manifestation. Many cases of mesothelioma are associated with relatively low levels of asbestos exposure. Mesothelioma is an incurable cancer and usually fatal within 1 to 2 years of diagnosis (ATSDR 2003).

Asbestosis is a serious, progressive, long-term disease of the lungs; it is not a cancer. Asbestosis is caused because inhaled asbestos fibers irritate and inflame lung tissues, causing the lung tissues to scar. This scarring makes breathing difficult and reduces the capability of the lungs to exchange oxygen and carbon dioxide. Asbestosis generally progresses slowly, with a latency period of typically 10 to 20 years after the initial exposures. The disease can vary from asymptomatic to disabling to potentially fatal (ATSDR 2003).

While epidemiologic studies do not clearly support a consistent relationship between nonrespiratory cancers and asbestos exposure, some epidemiologic studies have suggested an association between gastrointestinal (esophagus and stomach) and colorectal (colon and rectum) cancers and asbestos exposure. Some evidence shows that short-term (acute) oral exposure to asbestos might bring on precursor lesions of colon cancer, and that long-term (chronic) oral exposure might increase the incidence of gastrointestinal tumors (ATSDR 2003).

Studies have shown a small increase in the number of deaths from gastrointestinal and colorectal cancers related to asbestos exposures. For example, among 17,800 insulation workers, 99 people died from these cancers, even though the rate in the general population is expected to be 59.4 deaths. Among 2,500 asbestos textile workers, 26 people died from these cancers, but 17.1 deaths were expected. However, other mortality studies of asbestos workers found no significantly increased risk for these cancers (ATSDR 2003).

3.2.2 Other COPCs

Use of the site, including the operation of the barracks and the college campus, included activities that have been occasionally associated with the release of non-ACM COPCs at other sites. Although there is no indication yet that such releases at NRE occurred, areas of potential concern will be investigated in the RI/FS to determine the presence of COPCs and to rule out their presence where these constituents do not exist.

Candidate contaminants of concern include the following:

- **Volatile organic compounds (VOCs) in solvents that were used as degreasers or parts cleaners** – these contaminants have been found at other sites as a result of operations or disposal of used material.
- **Total petroleum hydrocarbons (TPH)** – oil and grease compounds also associated with machinery operations.
- **Polychlorinated biphenyls (PCBs)** – typically associated with electrical equipment, but also with a relatively broad array of uses as stabilizers.
- **Polynuclear aromatic hydrocarbons (PAHs)** – heavy organics associated with power plant operations.
- **Pesticides** – constituents such as DDT that were used for control of insects and other pests.
- **Metals** – constituents such as lead, which had a variety of uses including paint and leaded gasoline.

Background information on the site and its usage was evaluated to determine if the historical activities might have led to non-asbestos COPCs being released to the environment. Based on current background information, a number of historical areas of potential non-asbestos COPC releases were possible. These areas and the related potential non-asbestos COPCs are summarized as follows:

- **Rifle range** – possible lead and other metals and/or small rocket propellant from range usage.
- **Central power plant** – possible VOCs due to use for degreasing and cleaning operations; possible TPH and/or PCBs due to mechanical operations; possible PAHs from coal-firing operations and coal storage.
- **Known or suspected burial pits** – possible VOCs due to past disposal practices; possible semi-volatile VOCs (SVOCs), TPH, PCBs, pesticides, and/or metals from general site disposal practices.
- **Maintenance/repair shop** – possible VOCs due to use in degreasing and cleaning operations; and/or possible TPH and/or metals from machining and other operations
- **Laundry** – possible VOCs from mechanical or parts cleaning; possible SVOCs from past operations.

- **Possible landfill** – possible VOCs from past disposal; possible SVOCs, TPH, PCBs, pesticides, and/or metals from past disposal practices; possible wastes from past medical laboratory disposal practices.
- **Service station** – possible diesel, gasoline, motor oil, and/or used oil; possible VOCs, PAHs, and/or metals related to used oil.
- **Fire station** – possible petroleum fuels and/or motor oil from fire engine and equipment maintenance.
- **Water seep from crevice/ravine/landfill disposal area** – possible VOCs and/or SVOCs, TPH, PCBs, pesticides, and/or metals from water seepage through landfill and disposal areas upstream.
- **Lead-based paint** – possible lead due to past paint usage and sloughing of material.

Table 3-4 summarizes information reported by the ATSDR on the uses of these contaminants and related potential human health concerns.

Table 3-4. Uses of Contaminants and Potential Health Concerns

Name	Abbreviated Description (ATSDR)	Potential Health Concerns
VOCs	Examples: Trichloroethylene (TCE), Vinyl Chloride. TCE is used mainly as a solvent to remove grease from metal parts, but it is also an ingredient in adhesives, paint removers, typewriter correction fluids, and spot removers. Vinyl chloride can be formed when trichloroethane, trichloroethylene, and tetrachloroethylene degrade.	TCE may reasonably be anticipated to be a carcinogen. Vinyl chloride is a known carcinogen.
TPH	TPH is a term used to describe a large family of several hundred chemical compounds that originally come from crude oil. TPH is a mixture of chemicals, all composed mainly of hydrogen and carbon, called hydrocarbons. Some chemicals that may be found in TPH are hexane, jet fuels, mineral oils, benzene, ethylbenzene, toluene, xylenes, naphthalene, and fluorene, as well as other petroleum products and gasoline components. However, it is likely that samples of TPH will contain only some, or a mixture, of these chemicals.	The International Agency for Research on Cancer (IARC) has determined that one TPH compound (benzene) is carcinogenic to humans. IARC has determined that other TPH compounds (benzo[a]pyrene and gasoline) are probably and possibly carcinogenic to humans. Most of the other TPH compounds are considered not to be classifiable by IARC.
PCBs	PCBs are mixtures of up to 209 individual chlorinated compounds (known as congeners). There are no known natural sources of PCBs. PCBs have been used as coolants and lubricants in transformers, capacitors, and other electrical equipment because they do not burn easily and are good insulators. Products that may contain PCBs include old fluorescent lighting fixtures and electrical devices containing PCB capacitors, and old microscope and hydraulic oils.	The EPA and the IARC have determined that PCBs are probably carcinogenic to humans.

Table 3-4. Uses of Contaminants and Potential Health Concerns

Name	Abbreviated Description (ATSDR)	Potential Health Concerns
PAHs	PAHs are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances such as tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds, such as soot. Some PAHs are manufactured. PAHs are found in coal tar, crude oil, creosote, and roofing tar, but a few are used in medicines or to make dyes, plastics, and pesticides.	Some PAHs may reasonably be expected to be carcinogens.
Pesticides, Insecticides, Herbicides	Examples: DDT, DDD, DDE, dieldrin, aldrin. DDT (dichlorodiphenyltrichloroethane) is a pesticide once widely used to control insects in agriculture and insects that carry diseases such as malaria. DDE (dichlorodiphenyldichloroethylene) and DDD (dichlorodiphenyldichloroethane) are chemicals similar to DDT that contaminate commercial DDT preparations. DDD was also used to kill pests, but its use has also been banned. Aldrin and dieldrin are insecticides with similar chemical structures. From the 1950s until 1970, aldrin and dieldrin were widely used pesticides for crops such as corn and cotton.	IARC determined that DDT may possibly cause cancer in humans. The EPA determined that DDT, DDE, and DDD are probable human carcinogens.
Metals	Example: lead. Lead has many different uses. It is used in the production of batteries, ammunition, metal products (solder and pipes), and devices to shield X-rays. It was used in gasoline production, paints and ceramic products, caulking, and pipe solder.	Causes adverse effects on the brain and nervous system, especially in infants and young children.

3.3 SUMMARY OF PAST INVESTIGATIONS AND REMOVAL ACTIVITIES

The activities described in this section were conducted under authority of the AOC between EPA and MBK that was entered into on May 20, 2003 (see Section 3.1) and the Unilateral Administrative Orders (UAO) that EPA issued March 15, 2005 and April 12, 2005 .

3.3.1 2003 RP Investigation and Removal Activities

Investigations conducted at NRE in 2003 included activities performed by MBK as the responsible party (RP) and EPA lead activities. In 2003, MBK removal and investigation actions were conducted by Rose City Contracting, Aeolus, Inc., and PBS. Investigative activities conducted by the RP contractors included baseline and hot spot soil sample collection and residential air sampling. RP removal actions included surficial removal of ACM, hot spot removal, burial pile exploration, buried steam pipe assessment, and ACM burial site stabilization. EPA and their Superfund Technical Assistance and Response Team (START-2) contractor, E&E, conducted oversight of the actions conducted by RP-contracted companies.

3.3.1.1 Baseline and "Hot Spot" Soil Sample Collection

To evaluate the ACM content in soils over a large portion of the site, MBK hired Aeolus, Inc., who proposed the collection of composite soil samples prior to the removal of surficial ACM. Samples were collected in accordance with the *Preliminary Sampling and Analysis Plan* (Berman 2003a) and the *Sampling and Analysis Plan for a Fast-Track Sampling Program and the North Ridge Estates Site* (Berman 2003b). Samples were collected by PBS in June 2003. At that time, PBS also collected seven soil samples from concentrated ACM hot spot locations at the site identified by the EPA On-Scene Coordinator (OSC). These samples were collected to determine if samples from these specific areas had a larger number of fibers present in soil than the areas that were being sampled according to Berman 2003a and 2003b. Results are presented in Berman's *Final Soil Sampling Results and Preliminary Risk Assessment* document (Berman 2004). All of the asbestos structures observed, except for some structures collected from one hot spot sample, were chrysotile. Several amosite structures were observed in one hot spot sample (E&E 2005).

3.3.1.2 Residential Air Sample Collection

Residential air sampling was conducted by PBS at 22 site residences to evaluate the potential for asbestos from ACM in site soils to impact the air quality inside the residences (E&E 2005). The project design included air sampling from inside and outside of each residence simultaneously to evaluate the degree to which indoor airborne concentrations may be attributable to secondary sources, including soil tracked into a residence (Berman 2003a). A total of 46 indoor/outdoor air samples were collected at 22 residences. In addition, PBS collected three background samples each week on a hillside south of the site. The analytical results from the 46 samples and nine background samples were interpreted by Aeolus and are included in the *Preliminary Air Sampling Results for the North Ridge Estates Site* report; Table 3-5 summarizes the results of this sampling (Berman 2003a).

Table 3-5. Residential Air Sample Results (Berman 2003a)

Parcel ID	Sample Location	Asbestos Structure Count		Asbestos Concentration (S/cc)		Analytical Sensitivity (S/cc)		Asbestos Fiber Type
		7402	Short	7402	Short	7402	Short	
15A-01800	Indoors	1	-	1.00E-04	-	1.00E-04	-	Amosite
	Outdoors	1	-	1.00E-04	-	1.00E-04	-	Chrysotile
15B-00200	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15B-00400	Indoors	-	1	-	4.50E-04	1.00E-04	4.50E-04	Chrysotile
	Outdoors	-	-	-	-	1.00E-04	-	-
15B-00500	Indoors	1	1	1.00E-04	4.40E-04	1.00E-04	4.40E-04	Chrysotile
	Outdoors	-	-	-	-	8.00E-05	-	-
15B-00600	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15C-00100	Indoors	-	-	-	-	9.00E-05	-	-
	Outdoors	-	-	-	-	8.00E-05	-	-

Table 3-5. Residential Air Sample Results (Berman 2003a)

Parcel ID	Sample Location	Asbestos Structure Count		Asbestos Concentration (S/cc)		Analytical Sensitivity (S/cc)		Asbestos Fiber Type
		7402	Short	7402	Short	7402	Short	
15C-00200	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	1	-	1.00E-04	-	1.00E-04	-	Chrysotile
	Indoors	-	-	-	-	1.20E-04	-	-
	Outdoors	-	-	-	-	9.70E-05	-	-
15C-00300	Indoors	-	1	-	4.60E-04	1.00E-04	4.60E-04	Chrysotile
	Outdoors	-	-	-	-	1.00E-04	-	-
15C-00400	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15D-00500	Indoors	-	-	-	-	9.00E-05	4.10E-04	-
	Outdoors	-	-	-	-	9.00E-05	4.10E-04	-
15D-00600	Indoors	-	-	-	-	9.00E-05	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15D-00700	Indoors	-	-	-	-	9.00E-05	-	-
	Outdoors	-	-	-	-	9.00E-05	-	-
15D-00800	Indoors	-	-	-	-	9.00E-05	-	-
	Outdoors	-	-	-	-	9.00E-05	-	-
15D-00900	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	-	-	-	-	9.50E-05	-	-
15D-01200	Indoors	-	-	-	-	9.60E-05	3.80E-04	-
	Outdoors	-	-	-	-	9.10E-05	-	-
15D-01400	Indoors	-	-	-	-	1.00E-04	3.90E-04	-
	Outdoors	-	-	-	-	9.90E-05	-	-
15D-01500	Indoors	-	-	-	-	9.90E-05	-	-
	Outdoors	-	-	-	-	1.10E-04	-	-
15D-01500	Indoors	-	-	-	-	9.70E-05	3.80E-04	-
	Outdoors	-	-	-	-	9.70E-05	-	-
15D-02900	Indoors	-	-	-	-	9.00E-05	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15D-03300	Indoors	-	-	-	-	1.00E-04	-	-
	Outdoors	-	-	-	-	1.00E-04	-	-
15D-03400	Indoors	-	-	-	-	9.00E-05	4.10E-04	-
	Outdoors	-	-	-	-	9.00E-05	4.10E-04	-
15D-03500	Indoors	-	-	-	-	9.50E-05	3.90E-04	-
	Outdoors	-	-	-	-	9.50E-05	-	-
Background #1		-	-	-	-	9.00E-05	-	-
Background #2		-	-	-	-	9.00E-05	-	-
Background #3		-	-	-	-	9.00E-05	-	-
Background #4		-	-	-	-	1.00E-04	-	-
Background #5		-	-	-	-	1.00E-04	-	-
Background #6		-	-	-	-	1.20E-04	-	-
Background #7		-	-	-	-	9.30E-05	-	-

Table 3-5. Residential Air Sample Results (Berman 2003a)

Parcel ID	Sample Location	Asbestos Structure Count		Asbestos Concentration (S/cc)		Analytical Sensitivity (S/cc)		Asbestos Fiber Type
		7402	Short	7402	Short	7402	Short	
Background #8		-	-	-	-	9.80E-05	-	-
Background #9		-	-	-	-	9.90E-05	-	-

Note: S/cc – structures per cubic centimeter

7402 = Asbestos structures counted in accord with NIOSH Method 7402 (thickness > 0.25 um, length > 5 um, aspect ratio ≥ 3:1)

Short = Asbestos fibers counted by ISO 10312 that are between 0.5 and 5 um in length

3.3.1.3 Surficial and "Hot Spot" Removal Activities

The 2003 surficial and hot spot removal activities were completed by Rose City Contracting. The contractors walked the site to remove pieces of ACM 1 inch in diameter and larger. At the conclusion of the surficial removal on October 17, 2003, 7 tons of surficial ACM were removed from 25 developed residential properties and several MBK-owned lots. PBS reported that the majority of the material removed during the surficial pick up was CAB, with lesser amounts of roofing material, floor tile, and AirCell.

In addition to the surficial removal activities conducted in 2003, areas of concentrated ACM debris were identified on nine properties. According to PBS records, approximately 77 tons of excavated material was removed from the hot spot locations for disposal as contaminated material at the Klamath County Landfill. Table 3-6 summarizes the amount of ACM removed from each of the properties (E&E 2005).

Table 3-6. Summary of 2003 Removal Quantities (E&E 2005)

Location Tax Lot ID Number	Surficial Removal Quantity[a] (lbs)	Hot Spot Removal Quantity (lbs)
015A-00304	397	
015A-00307	27	
015A-01700	53	
015A-01800	122	
015B-00200	1,514	
015B-00400	968	41,200[b,c]
015B-00500	2,535	79,040[c]
015B-00600	362	
015C-00100	1,176	
015C-00200	1,265	500[b]
015C-00300	385	
015C-00400	159	
015D-00500	1,098	
015D-00600	355	
015D-00700	772	
015D-00800	284	
015D-00900	20	

Table 3-6. Summary of 2003 Removal Quantities (E&E 2005)

Location Tax Lot ID Number	Surficial Removal Quantity[a] (lbs)	Hot Spot Removal Quantity (lbs)
015D-01000	1,288	[d]
015D-01200	65	
015D-01400	13	
015D-01500	10	
015D-01600	4	
015D-02500, 02600, 02700	30	
015D-02900	416	[d]
015D-03000	204	
015D-03300	516	32,660[c]
015D-03400	67	
015D-03500	326	[d]

[a] The majority of the ACM was CAB, with lesser amounts of roofing material. Floor tile and AirCell were rare.

[b] The hot spot includes roofing material and CAB.

[c] *Removed by excavator; assume weight includes soil.*

[d] Removal was performed by hand pick up and is included in surficial removal weight.

Note: lbs = pounds

3.3.1.4 Burial Pile Exploration Activities

Burial pile exploration was also conducted during the 2003 removal actions. In general, areas with unnatural topography such as mounds or areas with high concentrations of surfacing ACM debris were investigated as part of the burial pile investigation. In October 2003, 13 suspected burial locations were investigated. Thirty-two test pits were excavated, resulting in the identification of eight burial piles on nine residential properties as containing ACM. According to PBS, the full horizontal and vertical extent of the piles was not determined (E&E 2005). Table 3-7 summarizes the burial plies investigated and identified during these activities, and any quantity of material removed.

Table 3-7. Summary of 2003 Burial Pile Investigation (PBS 2004a)

Location Tax Lot ID Number	Evidence and Location of Burial Pile	Burial Pile Investigation Results	Quantity of Material Removed (lbs)
015B-00200	Debris pile near foundation.	Pile does not contain ACM.	None
015B-00400	Debris pile on N property line.	Concentrated CAB debris in pile.	3,720
015B-00500	Steep to vertical slope W of house/deck.	Concentrated CAB debris in pile.	None
015B-00600	Void in SW corner filled with soil.	Void does not contain ACM.	None
015C-00300	Mound on downhill (NE) side of parcel.	CAB and concrete debris.	930
015D-00500	Low broad uneven mound on SW corner of parcel.	No test pits excavated; historical evidence suggests mound is a burial location for plastic wrapped steam lines covered with concrete demolition waste.	None
015D-00700	Pile on N side of property.	CAB found in debris pile.	1,860

Table 3-7. Summary of 2003 Burial Pile Investigation (PBS 2004a)

Location Tax Lot ID Number	Evidence and Location of Burial Pile	Burial Pile Investigation Results	Quantity of Material Removed (lbs)
015D-00800	Mound between house and Old Fort Rd.	CAB found in debris pile.	930
015D-01400	Former swimming pool filled is assumed to contain ACM, construction debris, and soil.	No test pits excavated.	None
015D-03000	Debris pile in NE corner.	Pile does not contain ACM.	None
015D-03400	Debris pile on NE side of lot.	Pile does not contain ACM.	None
015D-03500 and 015D-00900	Debris pile at property line.	Concrete debris with floor tile and mastic affixed; CAB and general construction debris.	1,860

Since several ACM burial locations were either concentrated ACM debris piles or areas where concentrated ACM was surfacing along a steep embankment, the EPA required stabilization in locations that were subject to rapid erosion. Seven burial piles were stabilized in 2004. Stabilization methods ranged from the placement of topsoil, water permeable fabric, and 6-inch minus rock; and the installation of water diversion piping. EPA also formally documented the locations for future actions at the site (E&E 2005). Table 3-8 summaries the locations of the seven piles that were stabilized and the stabilization remedy.

Table 3-8. Summary of 2003 ACM Burial Piles and Stabilization Remedies (PBS 2004b)

Location Tax Lot ID Number	General Description of Pile	Approximate Dimensions	Method of Stabilization/Control Utilized
015A-00304	N side into ravine; exposed by roof runoff erosion	67' EW x 15' NS x 10' thick	6" of clean fill laid over sloping surface, one layer of 6-mil poly laid over clean fill, one layer of geotextile fabric laid over poly, area covered with 6" minus rock. A 6" diameter drain was placed along the uphill boundary to divert surface runoff from roof drains.
015B-00400 and 015B-00200	On N 015B-00400 and SW 015B-00200 property line; moderate to heavy grass and shrub cover, some trees and pine needle cover; erosion in places	Approximately 5,740 ft^2	Owner did not allow access for completion of work.
015B-00500	Steep to vertical slope W of house/deck	56' long x 8' wide x 8' thick	Two sections of hillside W of the house were covered with 6-mil poly sheeting. Areas covered measure 31' by 8' and 11' by 8'.
015C-00300	Sage and other brush, grass vegetation; E slope is eroding	Northern portion – 60' wide x 42' long x 10' thick; Southern portion – 30' wide x 42' long x 6' thick	Rock was placed on sloping portion among existing vegetation to control erosion.
015D-00500	Low broad uneven mound on SW corner of parcel; some grass and sage	Approximately 1,424 ft^2	Pile delineated with posts.

Table 3-8. Summary of 2003 ACM Burial Piles and Stabilization Remedies (PBS 2004b)

Location Tax Lot ID Number	General Description of Pile	Approximate Dimensions	Method of Stabilization/Control Utilized
015D-01400	Covered with rock from hillside to W; sage bushes	52' wide x 110' long x 12' thick	Due to concern for continued compaction and voids, clean soil pushed into three cave-in areas atop retaining wall area fenced off and "no trespassing" signs placed on the fencing.
015D-03500 and 015D-00900	Typically vegetated mound on 015D-03500 E side and 015D-00900 W side; tall grass, shrubs, pine needle cover from trees	015D-03500: 28' wide x 200' long x 4' high 015D-00900: Southern portion - 52' wide x 90' long x 4' high; Northern portion – 80' wide x 90' long x 5' high	Areas are fenced, good natural ground cover. No controls placed.

Note: ft^2 – square feet

* Dimensions estimated.

3.3.1.5 Steam Pipe Investigation

As part of the 2003 removal activities, a geophysical survey was conducted at the site to locate buried steam pipe. Geopotential, a geophysical surveyor, conducted the buried steam pipe survey in July 2003. Several thousand feet of buried steam pipe were located with a magnetometer. Because of the construction activities that have occurred at the site, it is unknown if all the buried asbestos-insulated pipe has been identified. To confirm the presence of buried steam pipe along the routes identified by Geopotential, several test pits were excavated. The presence of steam pipe was verified when corrugated steel, which wrapped the insulated piping, was observed at depths ranging from 2 to 6 feet bgs (E&E 2005). Figure 3-1 shows the locations where piping was identified at NRE.

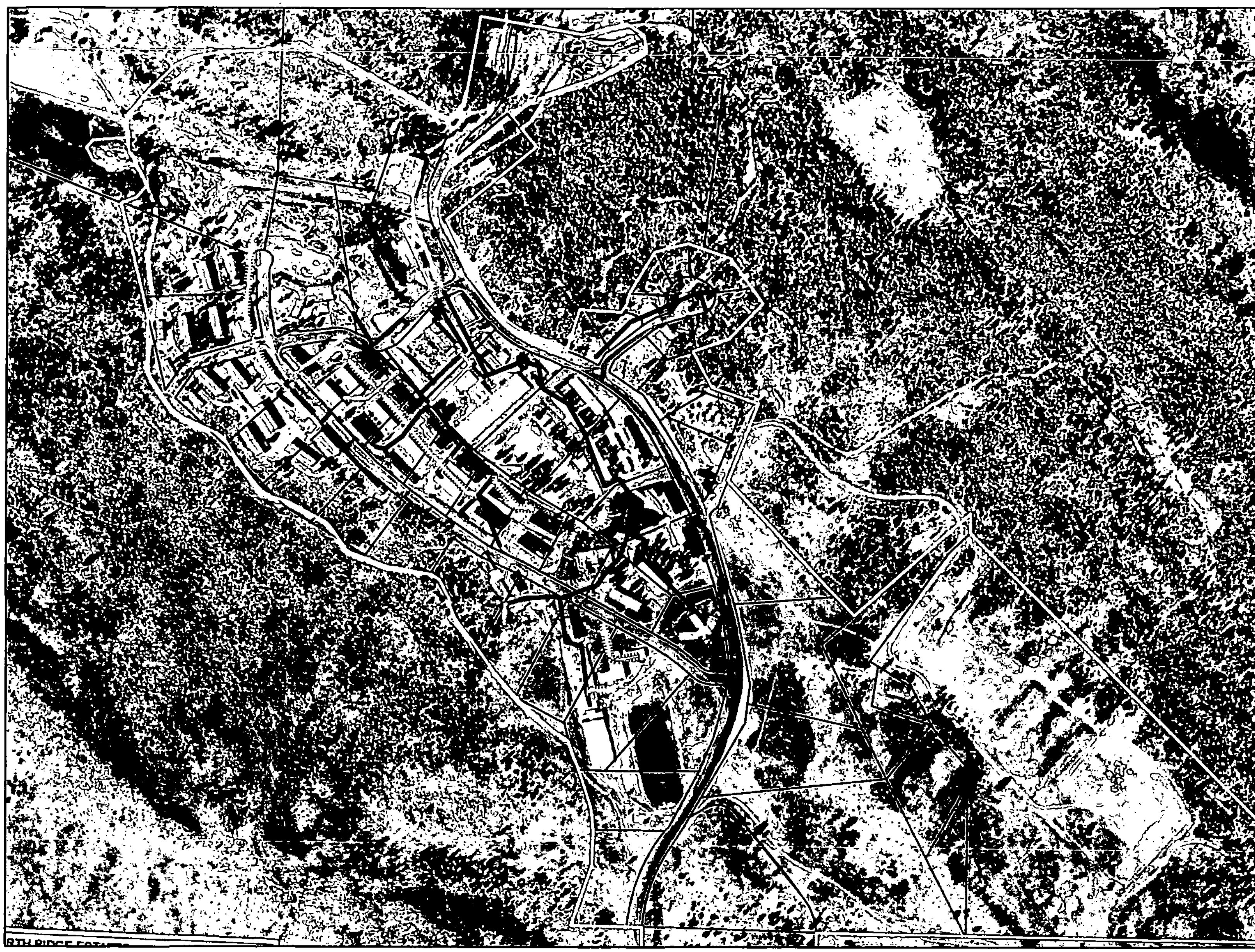

Figure 3-1
Location of Buried Piping

Legend

Parcels

Site Boundary

Steam Pipe
(Identified by PBS)

OTI Steam Lines
(Identified by Kennedy/Jenks)

Water Pipe
(Identified by Kennedy/Jenks)

N

0 0.05 0.1 0.15
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

Contact Information:
Parametrix
700 NE Multnomah
Suite 1000
Portland, OR 97232-2131
(503) 233-2400

April 2006

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Parametrix

Analysis by H.Gilbert; Analysis Date: 11-04-2006; Plot Date: 11-04-2006; File Name: Fig3-1_LocationsBuriedPiping.mxd

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3.3.2 2003 EPA Investigation Activities

EPA's START-2 contractor conducted activities, including residential soil sampling, ambient air sampling, and an assessment of lead in soil, delineation of lead-containing soils, and removal of lead-containing soils.

3.3.2.1 Residential Soil Sampling

Because residents and the EPA were concerned with the exposure from ACM on each residential property, EPA's START-2 contractor collected composite soil samples that were referenced to each property. Twenty-two residential properties were sampled, with 10 aliquots collected from each property to develop one composite sample per property. The aliquot locations were collected in targeted areas on each residence suspected of containing ACM and from areas on each property that were utilized frequently by residents. Samples were collected from 0 to 2 inches within an 8-inch by 8-inch template. As a result of collecting from this depth, visible ACM was obtained in many of the samples. Twelve of the 22 samples were randomly chosen and processed by both the elutriation and glove box methods. Table 3-9 shows results of asbestos structure counts utilizing the counting rules for the transmission electron microscopy (TEM) by International Organization of Standards (ISO) 10312 Method, phase contrast microscopy equivalent (PCME), and the Protocol structures (E&E 2005). Interpretation of this data is detailed in the preliminary risk assessment report submitted by Dr. Berman (Berman 2004).

Table 3-9. Elutriator and Glove Box Method Results for Residential Soil Samples Collected by E&E (E&E 2005)[a]

Location Tax Lot ID Number	ISO TEM Analysis (>5 microns)		PCME Analysis[b]		Protocol Analysis[c]	
	Elutriator	Glove Box	Elutriator	Glove Box	Elutriator	Glove Box
15D-02900	0	*1*	0	*1*	0	*1*
15A-01800	*1*	*2*	0	*2*	0	NA[d]
15D-03300	*6*	*18*	*2*	*8*	*4*	*4*
15B-00200	0	0	0	0	0	0
15B-00600	0	*2*	0	*1*	0	*1*
15B-00500	0	*2*	0	0	0	NA
15C-00200	0	*13*	0	*2*	0	NA
15D-03400	*1*	*11*	0	*4*	0	NA
15D-01200	0	*1*	0	0	0	0
15D-00500	0	*3*	0	*3*	0	NA
15D-01400	*1*	0	*1*	0	0	NA
15C-00100	*8*	*24*	*1*	*8*	*1*	NA

[a] Values represent the number of asbestos structures contained in the sample.
[b] PCME structures are longer than 5 microns with an aspect ratio greater than 3 to 1.
[c] Protocol structures are generally longer than 5 microns and thinner than 0.5 microns.
[d] NA – not applicable. The protocol reporting was not completed by the laboratory for this sample.

3.3.2.2 Ambient Air Sampling

Ambient air sampling was conducted at the site over several weeks in the fall of 2003 and spring of 2004 to assess general levels of airborne asbestos particles. Six high-volume air sampling devices were placed throughout the site to create an air sampling network. Samples were collected between August 20, 2003 and September 23, 2003 and on April 28 and 29, 2004. A total of 90 air samples were collected and submitted for analysis by TEM via the Modified EPA-II Method. Figure 3-2 shows the location of the sampling stations. Most of the ambient air samples yielded no asbestos structures counted. The highest concentration (0.004 S/cc) was detected in sample 04040205, which was collected from sample location Ee on April 23, 2003. Results are summarized in Table 3-10 (E&E 2005). Additional data from 2005 ambient sampling with lower analytical sensitivities should be in the forthcoming E&E report (E&E 2006).

Table 3-10. Ambient Air Sample Results (E&E 2005)

		Asbestos Structure Count		Analytical Sensitivity (S/cc)		Asbestos Concentrations (S/cc)		Fiber
Location	Date of Collection	7402	short	7402	Short	7402	short	Type
Aa	8/20/2003			1.0E-03				
	8/22/2003			1.0E-03				
	8/26/2003			2.0E-03				
	8/27/2003			1.0E-03				
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003			1.0E-03				
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				
	9/22/2003			1.0E-03				
	9/23/2003		1	1.0E-03			1.0E-03	Actinolite
Bb	8/20/2003			1.0E-03				
	8/22/2003			2.0E-03				
	8/26/2003		2	1.0E-03			3.0E-03	Chrysotile
	8/27/2003			2.0E-03				
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003			1.0E-03				
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				
	9/22/2003			1.0E-03				
	9/23/2003			1.0E-03				
Cc	8/20/2003			1.0E-03				
	8/22/2003			2.0E-03				
	8/26/2003			2.0E-03				
	8/27/2003			2.0E-03				

Table 3-10. Ambient Air Sample Results (E&E 2005)

		Asbestos Structure Count		Analytical Sensitivity (S/cc)		Asbestos Concentrations (S/cc)		Fiber
Location	**Date of Collection**	**7402**	**short**	**7402**	**Short**	**7402**	**short**	**Type**
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003			1.0E-03				
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				
	9/22/2003		1	1.0E-03			1.0E-03	Chrysotile
	9/23/2003			1.0E-03	3.4E-04			
Dd	8/20/2003			1.0E-03				
	8/22/2003			2.0E-03				
	8/26/2003			2.0E-03				
	8/27/2003			2.0E-03				
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003			1.0E-03				
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				
	9/22/2003		1	1.0E-03			1.0E-03	Chrysotile
	9/23/2003		1	1.0E-03			1.0E-03	Chrysotile
Ee	8/26/2003			1.0E-03				
	8/27/2003			2.0E-03				
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003			1.0E-03				
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				
	9/22/2003		1	1.0E-03			1.0E-03	Chrysotile
	9/23/2003		1	1.0E-03			1.0E-03	Chrysotile
Ff	8/26/2003			2.0E-03				
	8/27/2003			2.0E-03				
	8/28/2003			1.0E-03				
	9/3/2003			1.0E-03				
	9/4/2003	1		1.0E-03		1.0E-03		Actinolite
	9/5/2003			1.0E-03				
	9/17/2003			1.0E-03				
	9/18/2003			1.0E-03				
	9/19/2003			1.0E-03				

Table 3-10. Ambient Air Sample Results (E&E 2005)

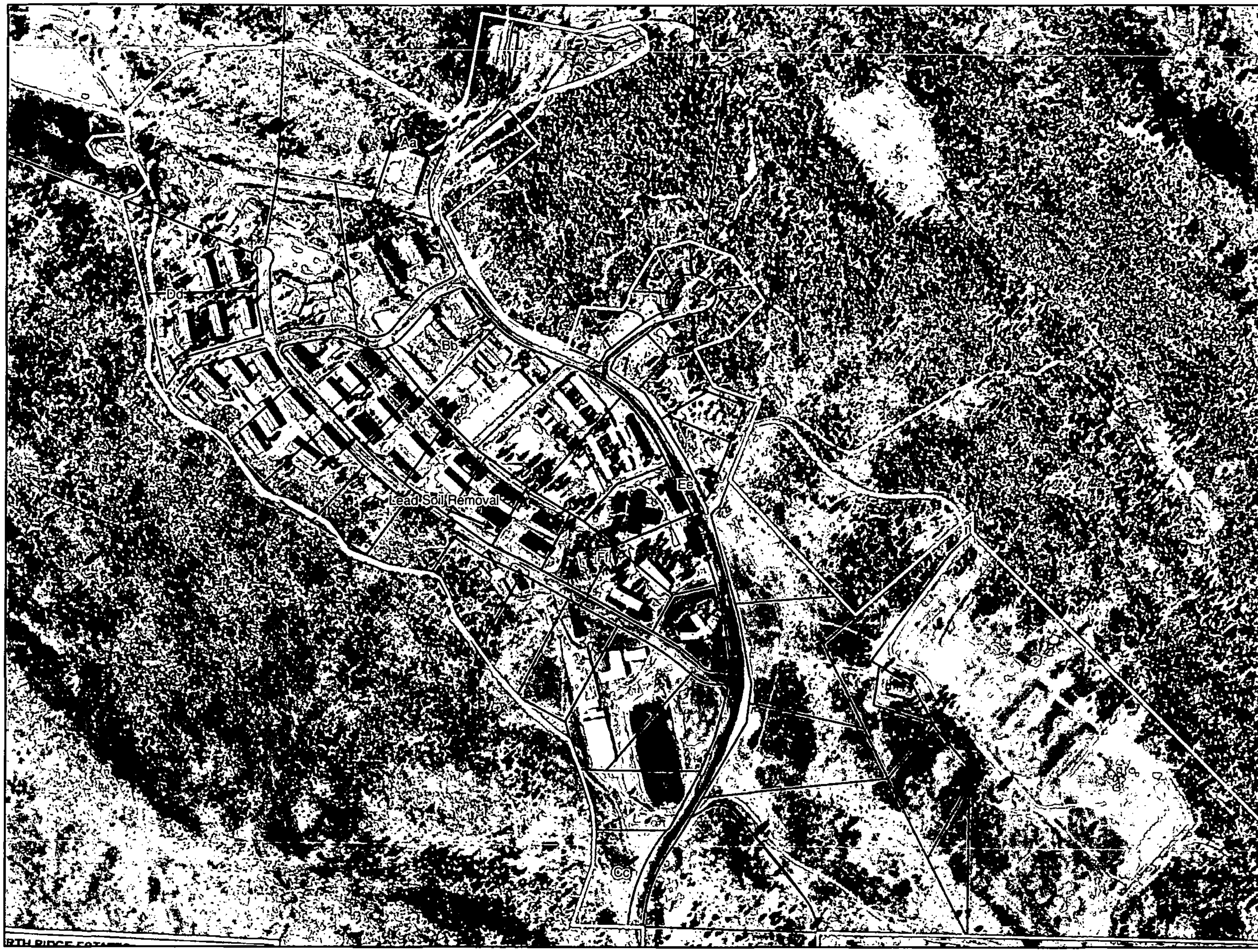
Location	Date of Collection	Asbestos Structure Count 7402	Asbestos Structure Count short	Analytical Sensitivity (S/cc) 7402	Analytical Sensitivity (S/cc) Short	Asbestos Concentrations (S/cc) 7402	Asbestos Concentrations (S/cc) short	Fiber Type
	9/22/2003			1.0E-03				
	9/23/2003		1	1.0E-03			1.0E-03	Chrysotile

Note: S/cc – structures per cubic centimeter

7402 = Asbestos structures counted in accord with NIOSH Method 7402 (thickness > 0.25 um, length > 5 um, aspect ratio ≥ 3:1)

Short = Asbestos fibers counted by ISO 10312 that are between 0.5 and 5 um in length

Figure 3-2
Locations of Ambient Air Sampling and Lead Soil Removal



Legend

- Parcels
- Site Boundary
- Lead Soil Removal
- Aa Ambient Air Stations

N

0 0.05 0.1 0.15
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

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3.3.2.3 Lead Soil Sampling and Removal

A secondary concern to the ACM contamination at the site is the presence of lead in soils potentially resulting from lead-based paint that coated most of the buildings and subsequently leached into the soils through either demolition activities or exposure to the elements. The START-2 contractor conducted soil sampling and analytical screening for lead in July 2003 to assess the extent of lead contamination in the site soils. A biased sampling approach was employed to identify potentially contaminated areas. Soil samples were collected from a total of 150 locations on 35 properties, targeting areas of visual soil staining, exposed soils, and where debris was visible. Thirteen duplicate split samples were collected as well. Field screening with x-ray fluorescence (XRF) was performed on-site by the START-2 contractor; approximately 12% of the samples field-screened by XRF were submitted to a fixed based laboratory. Confirmation analytical results from the fixed based laboratory indicated that only one sample exceeded the EPA Region 9 preliminary remediation goal (PRG) for lead in residential soil (400 milligrams per kilogram [mg/kg]). This sample was collected from one of the MBK properties, specifically, the property identified as MBK-C (15D-03200), and contained 1,500 mg/kg lead (E&E 2005).

To delineate the extent of contamination at the MBK-C (15D-03200) property, a concentrated soil sampling grid was established and an additional 49 samples were collected for lead screening. Based on this second sampling effort, it was determined that the area of soil with lead concentration greater than EPA Region 9 residential lead PRG was approximately 25 feet in diameter (E&E 2005).

3.3.2.4 PCB Soil Sampling

The use of PCBs in transformers located at the site has been suspected. On July 12, 2003, samples were collected at a site suspected of a PCB spill and field-screened using the Clor-N-Soil PCB screening kit. PCB screening results for the transformer site were less than 50 ppm (E&E 2005). No further actions were taken regarding PCBs at the site.

3.3.3 2004 Responsible Party Removal Activities

Based on the results of the delineation sampling conducted by the START-2 contractor in 2003, the RP agreed to conduct a removal of the lead-contaminated soil identified at the MBK-C (15D-03200) property. On October 6, 2004, soils were excavated to depths ranging from 1.5 to 2 feet, in a triangular area measuring 28 feet by 30 feet by 40 feet (Figure 3-2). Approximately 26.5 tons of material were removed and disposed of as lead-contaminated soil at the Klamath County landfill (E&E 2005).

3.3.4 2004 EPA Investigation Activities

EPA conducted activity-based sampling in July 2004 to assess the exposure risk associated with asbestos contained in site soils. Specific activities were conducted and the levels of airborne asbestos in the breathing zone and ambient air were measured. Three activities involving varying levels of soil disturbance were performed on-site to gauge the impact on airborne asbestos levels in the breathing zone: weed-trimming with an electric trimmer, tilling soil with a gas-powered rototiller, and a child playing in the dirt. Results of the activity-based sampling suggest that the highest exposure to PCME fibers occurred from the child play activity. The PCME asbestos concentration in the breathing zone for the child play scenario ranged from 0.014 to 0.015 S/cc. Results were <0.009 to 0.062 S/cc for the weed trimming activity and nondetect for the rototilling activity (E&E 2005).

Results of the activity based-sampling were reviewed by the EPA toxicologist and summarized in the technical memorandum *Activity-Based Air Sampling Results at North Ridge Estates* (Wroble 2004). The conclusions of the technical memorandum are:

> The results generally do not indicate risk levels elevated above the high end of EPA's risk management range of $1x10^{-6}$ to $1x10^{-4}$; however, they do indicate that fibers are released into air upon soil disturbance. Residents at NRE should continue to practice measures to limit exposure to ACM and asbestos fiber.

The activity-based sampling results were also reviewed by the RP contractor, Aeolus, Inc. (Berman 2005). Conclusions and recommendations by Aeolus closely parallel those of the EPA. Aeolus stated that "...for now, it would be prudent to limit intimate contact with local soils (especially children playing in such soils)", and that "...residential activities involving physical proximity to the soil while it is disturbed should be curtailed..." (Berman 2005).

In 2004, EPA and its START-2 contractor conducted a preliminary assessment and site inspection of the Kingsley Firing Range. Seven soil samples were collected from the horseshoe berm ordinance burn/disposal area, flat ordinance burn/disposal area, small arms impact berm, and rifle range and 3.5-inch rocket impact berm at the rifle range for nitrate base explosive compounds (NBECs) and/or metals analyses. NBECs were not detected. Lead and arsenic were reportedly detected at maximum concentrations of 1,220 mg/kg and 2.8 mg/kg, respectively. No significant concentrations of other metals were detected.

3.3.5 2005 RP and EPA Removal Activities

In 2005 removal actions were conducted by the RP and EPA in response to the large amount of AirCell and MAG that had surfaced at the site.

On April 26, 2005, EPA signed an action memorandum to request approval for a temporary relocation action for the NRE site. The relocation was voluntary, because EPA felt it was appropriate for immediate reduction of the risk to the public from uncontrolled release of asbestos at the site. In June and July of 2005, PBS, the contractor for the RP, completed the removal of 330 pounds (lbs) of MAG material from three properties at NRE.

Also in 2005, EPA completed a site-wide pick-up of the AirCell and MAG material. EPA contractors removed approximately 350 pounds of AirCell and MAG from 24 site properties. Figure 3-3 shows the locations where AirCell and MAG were observed during the 2005 EPA pick-up.

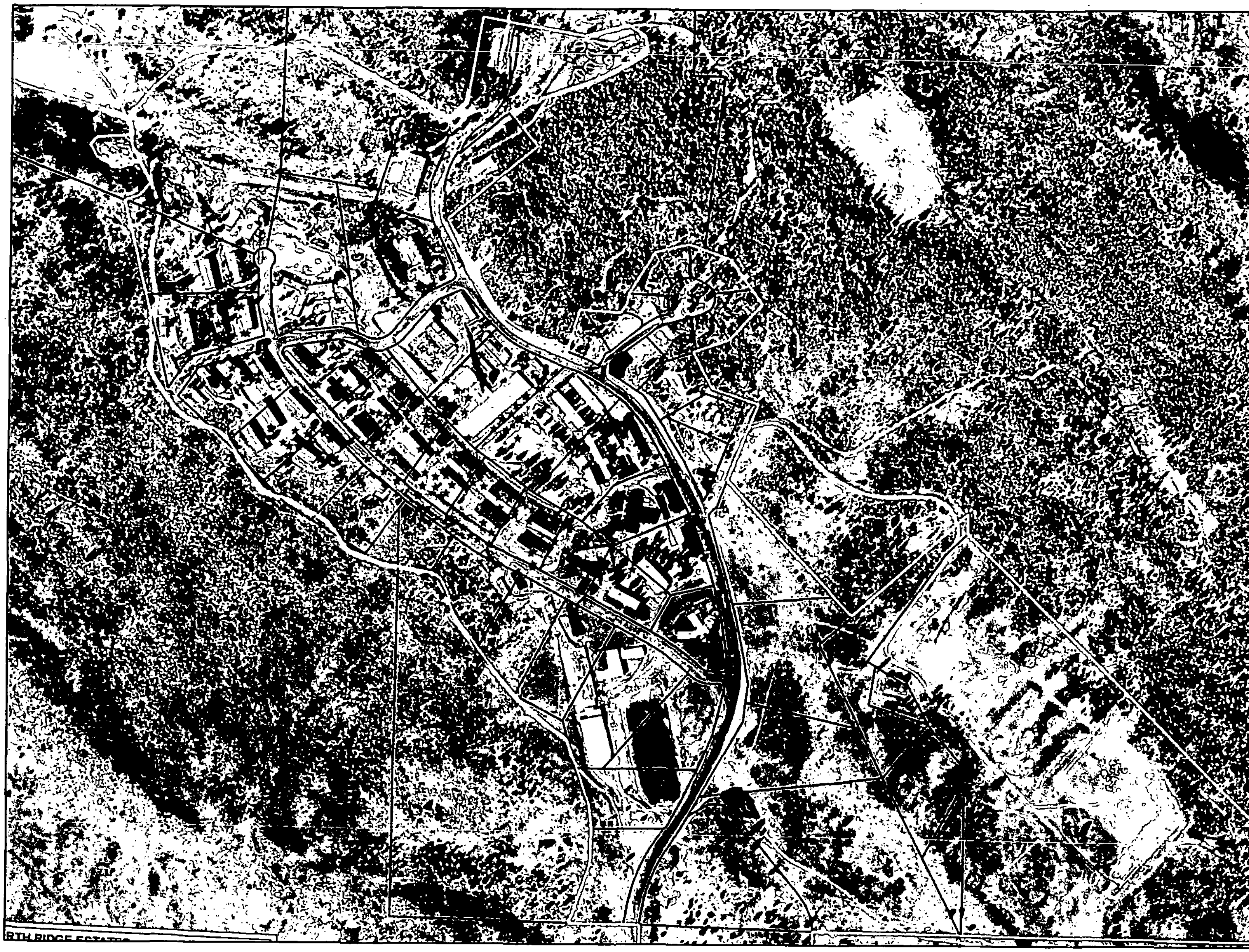
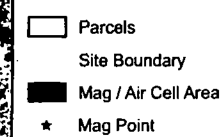
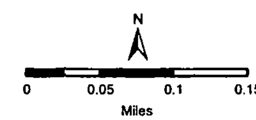


Figure 3-3
Location of Mag and AirCell Observed in 2005

Legend





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Projected Coordinate System:
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3.3.6 Unilateral Order for a PRP RI/FS

A UAO issued by EPA on March 15, 2005 and effective on April 4, 2005 directed the individual partners of MBK to conduct RI/FS activities at the site under the oversight of EPA. Key documents to be delivered and activities to be performed, to be consistent with CERCLA guidance and subject to EPA review and approval, included:

- Prepare and submit to EPA an RI/FS work plan
- Prepare and submit a Sampling and Analysis Plan (SAP), which included a Field Sampling Plan (FSP) and Quality Assurance Project Plan
- Prepare and submit a Site Health and Safety Plan (HASP)
- Prepare and submit a Community Relations Plan and a Technical Assistance Plan
- Perform site characterization
- Develop and submit to EPA a Baseline Risk Assessment
- Develop a Draft Remedial Investigation Report (RI)
- Perform treatability studies unless such studies were shown to not be required
- Develop and screen remedial alternatives
- Perform a detailed analysis of remedial alternatives
- Develop and Submit a FS report

The MBK partners were to also perform a number of other activities, such as progress reporting.

Per the consent order several of the draft documents were submitted for EPA review. The June 2005 legal settlement relieved MBK and the individual partners of further responsibilities for the RI/FS; therefore, EPA issued a Stop Work Notice to the MBK partners on July 18, 2005.

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4. SUMMARY OF FINDINGS

4.1 FINDINGS-TO-DATE

4.1.1 Asbestos

The types of ACM present at NRE include CAB, VAT, floor tile mastic, roofing material, and insulation (AirCell and MAG) and tar paper used in steam piping. The asbestos types in these materials are chrysotile and amosite, and asbestos content varies from <1% to 90% depending on the material (DEQ 2001; E&E 2006). ACM is currently present at NRE as insulation in buried steam piping, in known and suspected burial piles created during demolition activities, as surficial debris, and as fibers released during the migration of ACM to the surface or through degradation of surficial ACM by physical forces. ACM in at least one of these forms has been found on 40 parcels in the NRE subdivision. Figure 4-1 shows ACM previously found to exist at each parcel in the subdivision.

4.1.1.1 ACM in Steam Piping

ACM in steam piping exists as a metal corrugated pipe, 8 inches or larger in diameter, wrapped in black felt paper that contains chrysotile. The inside of the corrugated pipe is lined with a black felt paper that contains chrysotile, with approximately 2 inches of wooly material (amosite and chrysotile). A metal pipe approximately 4 inches in diameter is located in the center of this larger pipe; the metal pipe was used to transport the steam (DEQ 2004). Steam piping has been found from 2 to 6 feet bgs. Based on a geophysical survey and investigations by Kennedy/Jenks (Kennedy/Jenks 2005), 14,666 feet of buried piping exists at the site. Additional comments by Kennedy/Jenks suggest that 2,460 feet of this piping may actually be potable water service lines. Figure 3-1 shows buried piping that has been identified at the site from various sources.

4.1.1.2 ACM in Burial Piles

Based on PBS investigations, seven burial piles containing ACM are known to currently exist on properties in the subdivision (Figure 4-2). These piles range in height/depth from 4 to 12 feet, cover an estimated 35,597 ft^2, and contain an estimated 220,811 cubic feet (ft^3) (including soil). Tables 3-7 and 3-8 summarize the attributes of these known burial piles.

Additional ACM is suspected to exist at the site in large disposal areas, mounds, in-ground structures, shallow burial pits, and scattered surface debris. Locations of interest include the former rifle range, clarifiers at the former waste water treatment plant, and piles scattered throughout the residentially developed portions of the site.

4.1.1.3 ACM as Surficial Debris

Each spring since 2002, ACM has emerged at the NRE site as surficial debris, presumably due to the subsurface freeze-thaw cycle and surface erosion. Removal events in 2002, 2003, 2004, and 2005 have removed a total of 115,114 lbs, or 57.6 tons, of surficial ACM debris. Debris removed in 2003 and 2004 was described as mostly CAB with lesser amounts of roofing material. The content of debris changed in 2005, most notably, MAG and AirCell were observed more frequently than in previous years.

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Figure 4-1
North Ridge Estates
ACM/Asbestos as of Date

Legend

- XRF Lead Soil Samples
- Lead Grid
- Lead Hot Spot
- ACM Hot Spot Samples
- PBS Burial Pile-Test Pits
- Steampipe Investigation Test Pits

NRE 2005 Data Points

- Geoprobe Borings, Detect
- Geoprobe Borings, Non-Detect
- Mag
- Soil PLM Samples, Detect
- Test Pits, Detect
- Test Pits, Non-Detect
- Mag
- Mag / Air Cell Area
- Known ACM Burial Pile
- Steam Pipe (Identified by PBS)
- OTI Steam Lines (Identified by Kennedy/Jenks)
- Water Pipe (Identified by Kennedy/Jenks)
- Heavy/Hot Contamination
- Medium or Suspected Contamination
- Existing Buildings
- Parcels

N

0 0.05 0.1 0.15
Miles

Projected Coordinate System:
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Figure 4-2
Currently Known
ACM Burial Piles

Legend

Site Boundary

Known ACM Burial Pile

N

0 0.1 0.2
Miles

Geographic Data Standards:
Projected Coordinate System:
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4.1.1.4 Asbestos in Air

Asbestos structures have been detected in air samples collected both indoor and outdoors at the site.

PBS collected 22 indoor and 22 outdoor air samples at the site. Of the indoor samples, seven asbestos structures were detected in six samples. Of the seven asbestos structures detected, one was amosite and the remainder were chrysotile. The concentrations of asbestos structures detected in the indoor samples ranged from 9.9E-05 to 1.0E-04 S/cc. Of the outdoor samples, three asbestos structures were detected in three samples. All of the structures detected in the outdoor air samples were chrysotile. The concentration of asbestos structures detected in the outdoor samples was 1.0E-04 S/cc.

Seventeen of the 90 samples collected as part of the ambient air sampling network contained asbestos structures. Fifteen of the samples contained only one or two asbestos structures and had asbestos concentrations ranging from 0.001 to 0.003 S/cc. One sample contained three asbestos structures, equating to an asbestos concentration of 0.002 S/cc. The most asbestos structures detected in any one sample during this sampling event was five, with a resulting asbestos concentration of 0.004 S/cc.

Additional air sampling was conducted by the START-2 contractor in 2005 and will be presented in a report to be published later in 2006 (E&E 2006).

4.1.1.5 Asbestos in Surface Soils

Analytical results have shown the presence of asbestos fibers in surface soil samples at the site. A total of 16 surface soil samples collected by the START-2 contractor were submitted for polarized light microscopy (PLM) analysis in 2005. The results indicate that both amosite and chrysotile fibers are present in surface soils at the site. Concentrations range from 0.0002 to 0.05% (amosite) and 0.0005 to 0.21% (chrysotile).

4.1.2 Non-Asbestos COPCs

Previous investigations for non-asbestos contamination at the site included a preliminary soil investigation for lead and other metals and small rocket propellant at the rifle range, a soil investigation for lead throughout the site (because lead-based paint may have been used on former facility buildings), and a soil investigation for PCBs in electrical transformer areas.

Results of the previous investigations are summarized as follows:

- **Preliminary Rifle Range Soil Investigation**: Seven soil samples were collected at the rifle range: from the horseshoe berm ordinance burn/disposal area, flat ordinance burn/disposal area, small arms impact berm, and rifle range and 3.5-inch rocket impact berm. These samples were tested for NBECs and metals. NBECs were not detected. Lead and arsenic were reportedly detected at maximum concentrations of 1,220 milligrams per kilogram (mg/kg) and 2.8 mg/kg, respectively. These concentrations are above background levels for the site and EPA Region 9 PRGs for lead and arsenic at residential sites of 400 mg/kg and 0.39 mg/kg, respectively. The arsenic concentration is well below levels that Oregon considers being background (7 mg/kg); therefore, based on this dataset, DEQ would not consider arsenic to be a COPC in this portion of the site. No significant concentrations of other metals were detected. The preliminary rifle range investigation was limited to the areas described above.

- **Subdivision Lead-Based Paint**: Soil samples were reportedly collected from 150 locations throughout the NRE subdivision and screened in the field for lead using an XRF Spectrometer. XRF readings indicated elevated concentrations of lead in two of the samples, one collected from Tax Lot 15D0-02900 (444 parts per million [ppm]) and one collected from Tax Lot 15D0-03200 (1,030 ppm). These two samples were submitted to a laboratory for further lead analysis using EPA Method 7000B. Lead was detected at concentrations of 320 mg/kg and 1,500 mg/kg in the samples from Tax Lots 15D0-02900 and 15D0-03200, respectively. The EPA Region 9 PRG for lead at a residential site is 400 mg/kg.
- **Transformer Site PCBs**: Soil samples collected at transformer sites were reportedly screened in the field for PCBs using a Clor-N-Soil screening kit. All samples were less than the detection limit of 50 mg/kg for the screening kit, which is below EPA Region 9 PRGs for PCBs. The EPA Region 9 PRGs for residential sites are 3.9 mg/kg for low risk (e.g., Aroclor 1016) and 0.22 mg/kg for high risk (e.g., Aroclor 1254) PCBs.

4.2 ACM FATE AND TRANSPORT MODEL

4.2.1 Reappearance of Friable ACM

The ACM was brought to the site in the form of building materials used to construct the MRB in 1944. Nearly 80 buildings were constructed using an estimated 1,500 tons of ACM building products. Six buildings were demolished over the next 20 years. The location of ACM contained in these buildings is not known. The other buildings remained essentially intact until the mid-1960s, when ACM was separated from salvageable materials contained in the buildings and left on-site. In the late 1970s, many of the buildings were demolished and burned, and the remaining unburnable materials (ACM, metal, glass, concrete) were buried on-site. The boiler and the gymnasium were demolished in the early 1990s without removal of the ACM and disposed on-site. Subdivision and home construction began at the site in the early 1990s.

Most of the ACM at the site was non-friable at the time of construction in 1944. However, the ACM has become friable due to a number of processes and actions at the site. These include:

- Above-ground weathering of the ACM binders, resulting in the release of asbestos fibers.
- Fracturing and pulverizing of ACM binders, resulting in the release of asbestos fibers during building demolition, bulldozing and burial.
- Fracturing, degradation or destruction of the ACM binders when burned. Cement binders would have been degraded and fractured when burned; organic binders contained in roofing, tar paper, tile flooring, and mastic would have been destroyed when burned.
- Below-ground chemical and physical weathering of the ACM binders when buried. Chemical weathering could result from exposure to organic acids and enzymes. Physical weathering could result from fracturing due to freezing and thawing, root penetration, and digging or chewing by animals.

Most of the estimated 1,500 tons of ACM at the site is buried. The depth of burial varies throughout the site from 0 feet to 12 feet or more.

There are a number of processes that result in the movement of the ACM and asbestos fibers found below and at the ground surface. These are summarized below:

- Migration to the ground surface. It has been observed that ACM pieces migrate to the ground surface over time. Areas cleared of ACM during one summer were found to have visible amounts of ACM at the ground surface the following summer. This upward migration is considered to be driven primarily by freeze/thaw cycles. The specific mechanisms that cause the movement are unknown but may be due to the lower density of the ACM than surrounding soils, and "frost jacking" of the ACM resulting from uneven freezing and thawing of the moisture in the soil around the ACM.
- Transport to the ground surface by burrowing animals. Burrowing animals can transport buried ACM and asbestos fibers to the ground surface while removing soil for tunnels and dens. The excavated soil containing ACM and asbestos fibers have been observed spread on the ground surface near the openings to the tunnels.
- Mechanical wedging and jacking by plant roots. Soil containing ACM and asbestos fibers can be moved by root growth. Fracturing of large pieces of ACM can occur from root growth expanding into cracks in the ACM. Root growth near the ground surface may wedge and lift the lighter and larger pieces of ACM, driving them upwards toward the surface.
- Erosion of surficial soil. Erosion of surface soils can cause buried ACM and asbestos fibers to be exposed at the ground surface, and can result in transport of surface ACM and asbestos fibers. Erosion rates will be higher in areas with steep slopes, in areas without vegetative cover, and in areas of surface water flow.
- Site development. The soils at a site are typically disturbed during construction of buried utilities, roadways, and building foundations, and during landscaping. Removal and transport of shallow soils for these purposes can result in buried ACM and asbestos fibers being exposed at the ground surface.

4.2.2 Conceptual Exposure Model

The existence of friable ACM in the subsurface and its reappearance on the soil surface, breakdown, and potential release of fibers into the environment creates a number of pathways for human exposure. Figure 4-3 outlines the conceptual model and pathways of exposure to fibers by residents and construction workers at the site.

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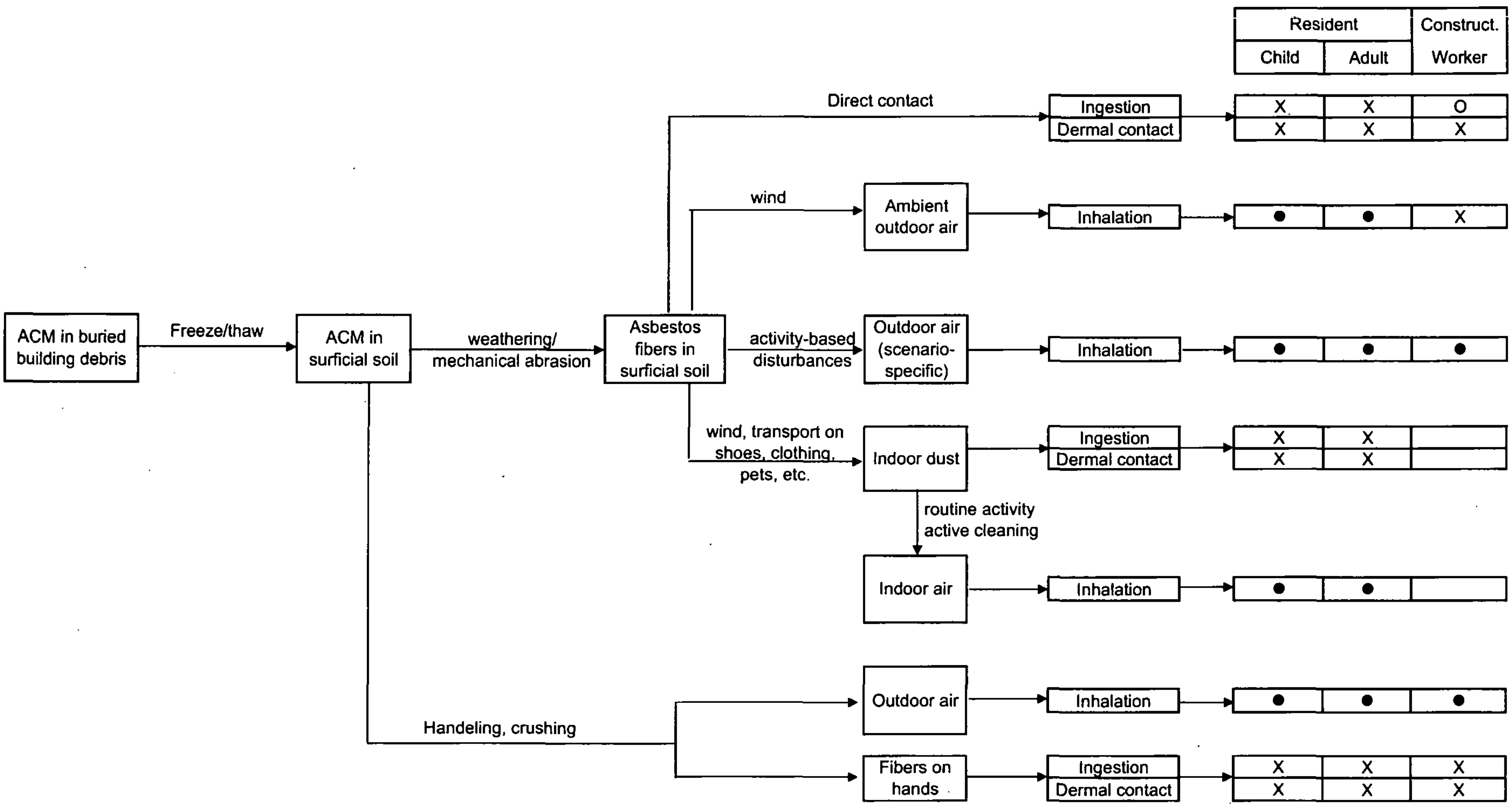
FIGURE 4-3. SITE CONCEPTUAL MODEL FOR EXPOSURE TO ASBESTOS IN SOIL



KEY

●	Pathway is complete and potentially significant; quantitative evaluation
O	Pathway is complete and potentially significant; however, data are lacking to support quantification; qualitative evaluation
X	Pathway is complete but is minor source of concern; qualitative evaluation
	Pathway is not complete

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4.3 SUMMARY OF KEY ISSUES

From the forgoing analysis, the following are key issues to be examined during the RI/FS:

- There is a known reappearance of currently buried friable ACM in surface soils. Surficial ACM can break down and will lead to release of asbestos fibers to soil that ultimately has the potential to lead to human exposure to the asbestos fibers. Exposure to asbestos fibers can lead to potential health impacts. The reappearance of friable ACM is expected to continue. The future impacts of this material will be evaluated. The approach to estimate potential future exposure risks from this material is presented in Section 5.
- There is a potential risk to current residents from exposure to asbestos fibers that have already been released to surface soils and may be present in the residents' homes. These risks can be presented by exposure to indoor air and dust or by outdoor activities that could disturb soils containing the fibers. The potential for current health risk to residents who remain at the site will be evaluated. The approach to estimate risk to current remaining residents is presented in Section 6.
- There are several relatively large land units where large quantities of ACM are known or suspected to have been disposed. In several cases non-ACM COPCs may also be present in those units. For purposes of FS analysis, the presence, condition, and approximate quantity of the material in these land units will be determined. The large land unit analysis will allow for evaluation of potential remedial alternatives. The approach that will be used to evaluate the large land units is presented in Section 7.
- Various historical human activities at the site have been known, at similar sites, to result in the release of hazardous substances into media such as soil, including activities associated with operation of the barracks facility and university and with demolition of buildings associated with those operations. It is possible that these hazardous substances are present at concentrations exceeding health-based criteria. However, except in a limited number of cases, the presence of these substances at the site has not been determined. The presence of hazardous substances other than asbestos will be evaluated in the RI/FS. If these substances are present above levels of concern, remedial actions will be evaluated. The approach that will be used to evaluate the possibility of COPCs in suspect locations and the approach to evaluate data obtained is presented in Section 8.

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5. BASIC APPROACH TO THE RI FOR ASBESTOS

The main purpose of the RI/FS is to evaluate remedial actions for addressing unacceptable risks from contaminants at the site. The question which the RI/FS must answer is: "For a given parcel of land (decision unit), is the current and future risk posed by the contaminants acceptable (no remediation needed) or unacceptable (remediation is required)?" At NRE, the site encompasses many individual properties, and each property contains one or more decision units. This section describes how the NRE properties will be classified based on the potential risk from asbestos.

5.1 LAND USE

The following conditions concerning land use at the NRE site are relevant to this analysis:

- The site is currently zoned by Klamath County and used as a residential development. This zoning and usage is presumed to continue into the future, and that presumption is the basis for the evaluation of risk and assessment of remedial alternatives for the site. EPA will consult with Klamath County should the site be rezoned in the future.
- Many current site residents will vacate their homes and transfer ownership to a Receiver by June 1, 2006, under the terms of a court-approved settlement agreement. However, a few residents will continue living at the site. Vacated properties are expected to remain vacant until a cleanup plan is approved by EPA.

5.2 CONVENTIONAL RISK EVALUATION/CHARACTERIZATION APPROACH

Figure 5-1 summarizes the general strategy that EPA would normally follow in evaluating any particular parcel of land (a decision unit) at the site in order to determine if the amount of asbestos and ACM present is above a level of potential human health concern, either now or in the future. The process consists of three sequential evaluations, as follows:

- Evaluation of current risks from free asbestos in surface soil
- Evaluation of future risks from ACM currently at the surface
- Evaluation of future risks from ACM and free asbestos in subsurface soil

5.2.1 Evaluation of Current Risks from Free Asbestos in Surface Soil

Because ACM has been coming to the surface at the NRE site for several years, some of this material may already have broken down and caused release of asbestos fibers to soil. In addition, free fibers generated during building demolition may also have contaminated surface soil.

Methods for the evaluation of risks from asbestos in soil are conceptually similar to the methods used by EPA for risks from other chemicals in soil, but are more difficult because of several technical issues, including:

- Absence of established analytical methods for the analysis of free asbestos in soil, especially for levels below about 1% by mass
- Uncertainty in the quantitative relationship between asbestos in soil and the resultant level of human exposure to airborne fibers

- Uncertainty in the relationship between the level of human exposure and the resultant risk of cancer (lung cancer and mesothelioma)

Nevertheless, based on the best data available at the present time, it is possible to derive estimates of the level of free asbestos fibers in soil that are likely to be of potential heath concern, as detailed in Appendix A. Values derived using EPA's recommended risk model (USEPA 1986, Integrated Risk Information System [IRIS] 2006), denoted as risk-based concentrations (RBCs), are summarized in Table 5-1.

Table 5-1. Summary of Cancer Risk and Associated Risk-Based Concentrations

Maximum Acceptable Excess Cancer Risk	Risk-Based Concentration (PCM S/g soil)
1E-04	6.9E+06
1E-05	6.9E+05
1E-06	6.9E+04

Notes:
Calculations for RBCs are based on IRIS 2006.
S/g – structures per gram.

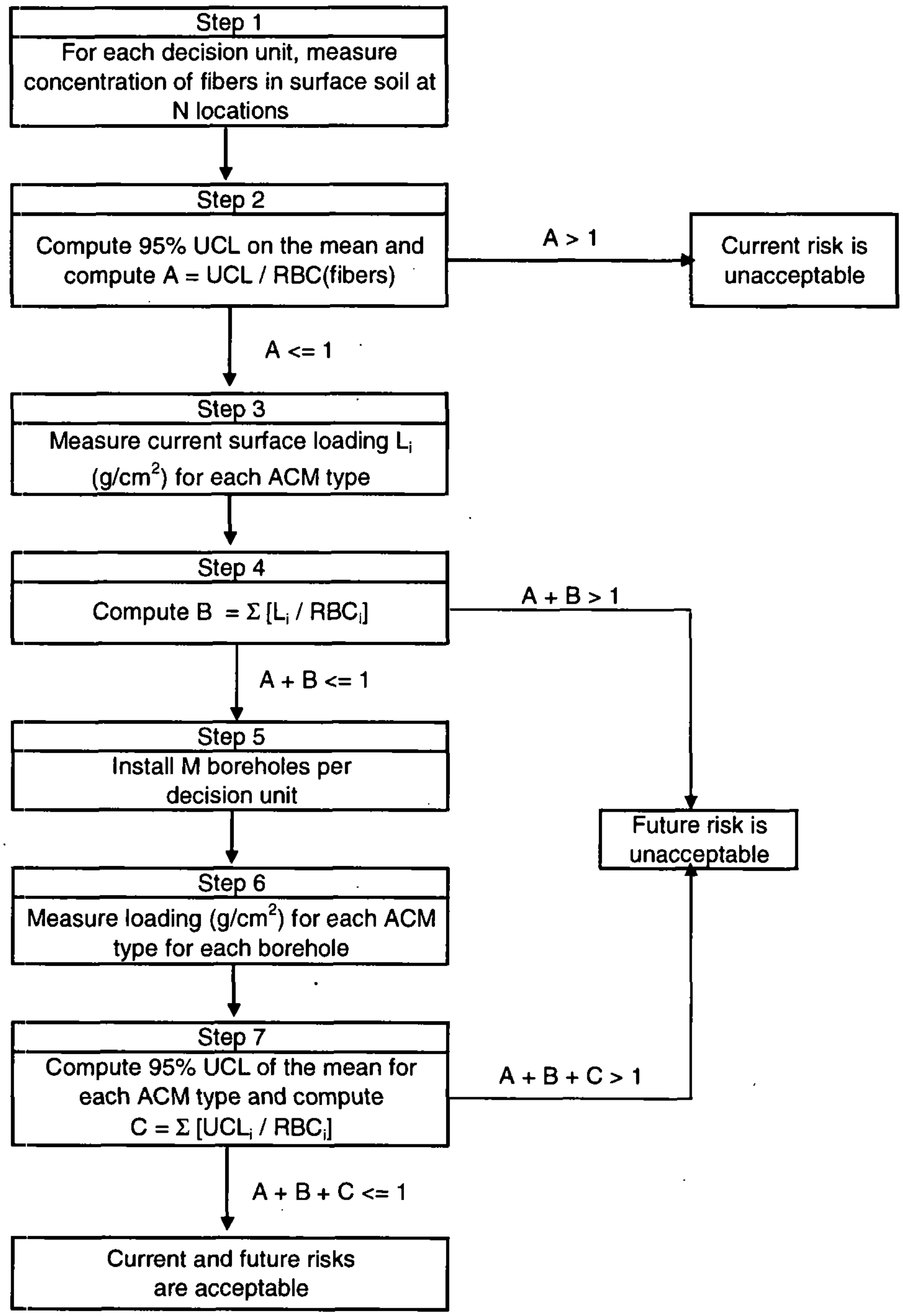

Figure 5-1
Conventional Sampling and Decision Strategy for Surface and Subsurface Soil

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February 2006

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Analysis by H.Gilbert; Analysis Date: 13-02-2006; Plot Date: 17-02-2006; File Name: Fig5-1_SamplingandDecisionStrategy.mxd

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In accordance with the standard procedures used by EPA at most Superfund sites and other hazardous waste areas, the procedure which EPA would typically follow in order to evaluate the risk from free asbestos fibers in surface soil at any decision unit consists of the following steps:

1. Collect a representative set of N samples of surface soil from within the area.
2. Measure the amount of free asbestos fibers in each sample, expressed in units of PCME S/g soil. Note that current methods for measuring free asbestos fibers in soil usually have detection limits that are at or greater than 2E+07 S/g, so attempts to investigate risks below 1E-04 are technically infeasible.
3. Compute the average concentration and the 95% upper confidence limit (UCL) on the mean concentration using EPA's ProUCL software. The UCL equation that is likely to be preferred is based on the Chebychev inequality method.
4. Compare the 95% UCL to the RBC selected for decision-making. If the 95% UCL exceeds the RBC, EPA will conclude that there is insufficient evidence to conclude that risks are acceptable under current circumstances, and will declare that the area is unacceptable.

In making this decision, two types of decision error are possible:

- *False negative.* In this case, the true concentration in the decision unit is above the RBC, but the UCL is below the RBC. The probability of this error occurring is, by definition, no greater than about 5% (assuming that the 95% UCL has been calculated appropriately). This level of error is generally considered to be acceptable for the protection of human health, since the errors will be rare, and when they occur, the magnitude of the error will typically be very small.
- *False Positive.* In this case, the true concentration in the decision unit is below the RBC, but the UCL is above the RBC. The probability of this error occurring depends on the number of samples collected, with the chances of false positives tending to decrease as the number of samples increases. The exact number of samples needed depends on the acceptable rate of false positives, as well as the underlying distribution of values, the average value, and the between-sample variability in the decision unit.

The number of samples collected at a decision unit is usually chosen to limit the probability of a false positive decision to some specified level. For example, the goal might be to have no more than 20% false positives when the true concentration is 1/2 the level of concern.

Because sufficient surface soil data are not yet available to identify the expected distributional form, the expected mean, or the likely between-sample variability, it is not possible to calculate the probability of decision error as a function of sample number with certainty. However, for screening purposes, it is assumed the distribution is likely to be approximately lognormal, and that the standard deviation will be about equal to the mean (CV = 1). Based on this, the relationship between sample number and the frequency of false positives is as shown in Figure 5-2. As seen, if the true mean is 1/2 the RBC, the frequency of false positives at 1/2 the level of concern is about 50% for N = 10, 20% for N = 20, and close to zero for N = 50.

Based on this, it is concluded that the number of samples needed for evaluation of surface soil to limit the probability of false positive decisions to an acceptable level is likely to be at least 20 (and perhaps more) per decision unit.

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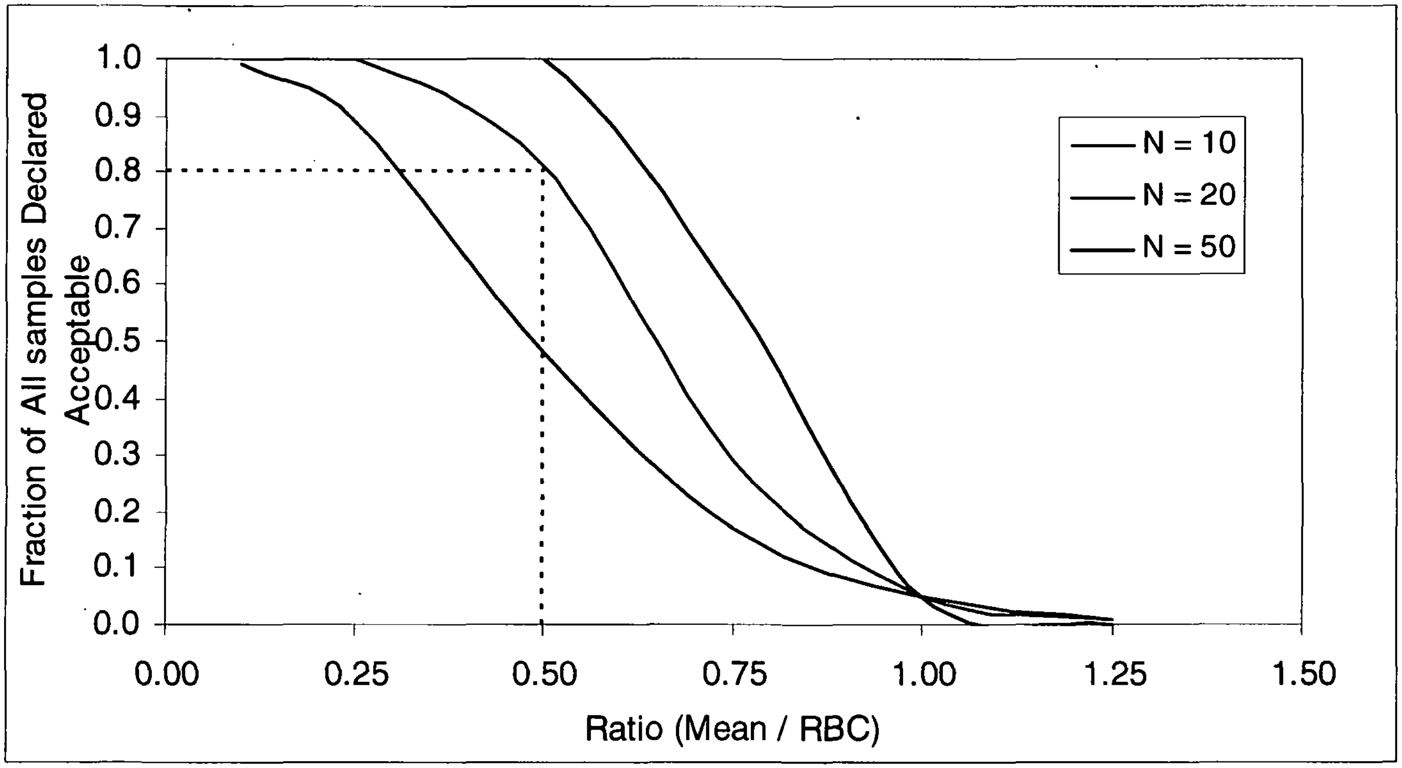

Figure 5-2
Simulated Decision Error Rates for Surface Soil Sampling

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5.2.2 Evaluation of Future Risks from ACM Presently at the Surface

Macroscopic pieces of ACM that exist on the surface of the ground are too large to be respirable, and hence do not pose a health risk until they begin to undergo degradation and release fibers into air or soil. For the purposes of this evaluation, attention is focused on the maximum future risk which would occur if pieces of ACM were to break down entirely and 100% of all fibers in the ACM were released to soil. It is likely that process would take a substantial number of years for some types of ACM (e.g., CAB, floor tile, roofing material), but might occur relatively quickly for other types (AirCell, MAG).

In order to evaluate risks from ACM presently at the surface, EPA would perform a manual pickup of the ACM from the decision unit. The amount of each type of ACM picked up (expressed as grams per square centimeter [g/cm^2]) would be compared to the corresponding RBCs for ACM, derived as detailed in Appendix A and Appendix B. These values, based on a target risk of 1E-04, are summarized in Table 5-2.

Table 5-2. Summary of Risk-Based Concentrations for ACM Types

ACM Type	Risk-Based Concentration (1E-04) g ACM/cm^2	Risk-Based Concentration (1E-04) Area Fraction
CAB	0.088	10.0%
Floor tiles	0.188	41.0%
Roofing	0.015	4.5%
AirCell	0.016	2.3%
MAG	0.024	3.1%

The total risk from all ACMs combined would be computed as the sum of the ratios multiplied by the risk value associated with the RBCs:

$$\text{Risk (total)} = 1\text{E-04}\ \Sigma\ (C_i / RBC_i)$$

While it is understood that a manual pickup of ACM from a specified area may be less than 100% complete (due to small pieces being overlooked), the resulting mass per unit area values would be treated as if there were no uncertainty, since both mass and area can be measured with good accuracy and there is no variability between different measurements.

5.2.3 Evaluation of Future Risks from ACM in Subsurface Soil

As noted above, observations at the site indicate that ACM that is presently contained within subsurface soil is tending to become exposed at the surface due to a combination of forces, including surface erosion and frost heave. For the purposes of this evaluation, the goal of the sampling is to estimate the total amount (mass) of ACM that exists in subsurface soil and that could be brought to the surface in the future and, from this mass, to estimate the maximum amount of free asbestos fibers that could be released to surface soil in the future.

Measuring the amount of ACM in subsurface soil is a difficult undertaking. EPA would generally perform this evaluation by installing a number of boreholes into the subsurface soil, each to a depth equal to the maximum depth from which pieces of ACM may migrate upward (this is approximately equal to the frost depth). The soil from each borehole would be inspected and all pieces of ACM would be isolated, grouped by type, and weighed. Thus, each borehole would yield a value of mass per unit area for each ACM type. The values for each ACM type would then be averaged across boreholes, and the 95% UCL for each would be computed using EPA's ProUCL software. The UCL would be divided by the RBC (g/cm^2) for each ACM type, and the ratios summed across all ACM types present. This ensures that additivity of risks from different ACM types are properly accounted for. If the sum of the ratios does not exceed 1, the risks from subsurface soil would be considered acceptable, while if the sum exceeds 1, risks would be considered potentially unacceptable.

In considering the number of boreholes that would have to be installed, the first step is to identify the *minimum* number required to detect ACM contamination if it were present at a level of concern. For this effort, the minimum number of boreholes required is defined as the number such that there is at least a 95% probability that one or more boreholes will intercept the ACM when it is present at a level of concern. Table 5-3 shows the minimum number of boreholes required as a function of the area fraction of concern.

Table 5-3. Minimum Boreholes Required

Area Fraction of Concern	Minimum Number of Boreholes
1%	299
2%	149
3%	99
5%	59
10%	29
15%	19

As noted above, based on EPA's IRIS risk model, the ACM type with the smallest area fraction of concern is AirCell (2.3% at a target risk of 1E-04), and the minimum number of samples required for this area fraction is 129. Based on this, the minimum number of boreholes that would be acceptable for each decision unit at a risk level of 1E-04 is about 130. If a risk level of 1E-05 or lower were selected, the area fraction of concern would be 0.23%, and the minimum number of boreholes per decision unit would be 1,300 or more.

Use of the minimum number of boreholes is expected to ensure that decision units with true concentrations of asbestos exceeding the RBC are likely to be detected, but may also be associated with a substantial risk of false positives. Because sufficient data are not yet available to identify the expected distributional form or the likely between-sample variability for ACM in subsurface soil, it is not possible to calculate the relation between sample number and false positive rate with certainty, but a screening level assessment can be performed using Monte Carlo modeling, as described in Appendix B.

The modeling results are shown in Figure 5-3. As seen, the false positive rate is expected to be very high, even if a large number of boreholes (> 500 per decision unit) were installed. This pattern does not depend on the type of ACM present. Based on these simulations, it is expected that very few decision units could ever be declared clean (i.e., not requiring remediation) based on the results of a reasonable number of boreholes, even when the true level of ACM contamination is 1/2 or less of the true level of concern.

Thus, even a significant (i.e., bordering on impractical) drilling and sampling program across all decision units on the site would not enable EPA to distinguish acceptable from unacceptable levels of future risk from buried ACM. Consequently, this type of evaluation will not be performed.

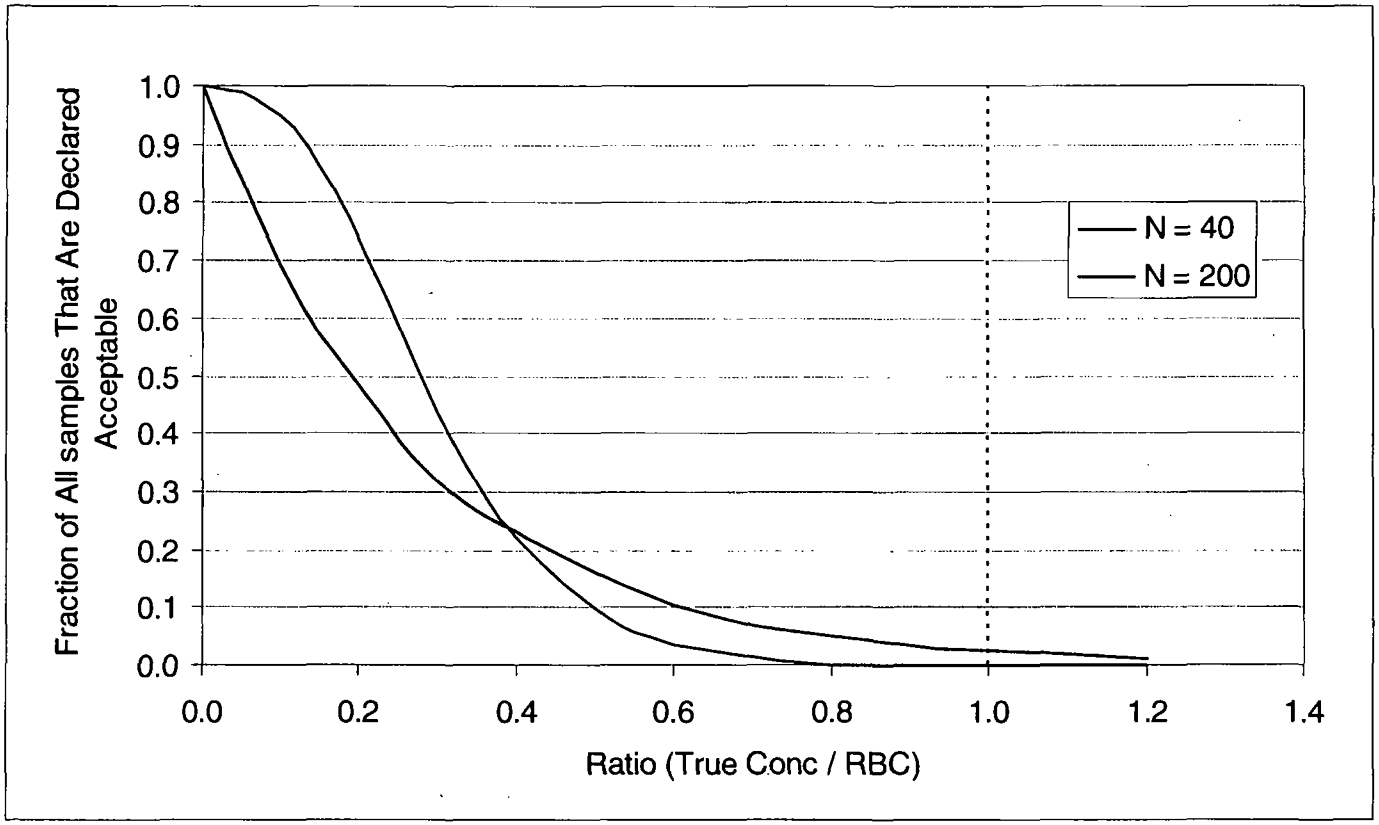

Figure 5-3
AirCell (IRIS Risk Model)

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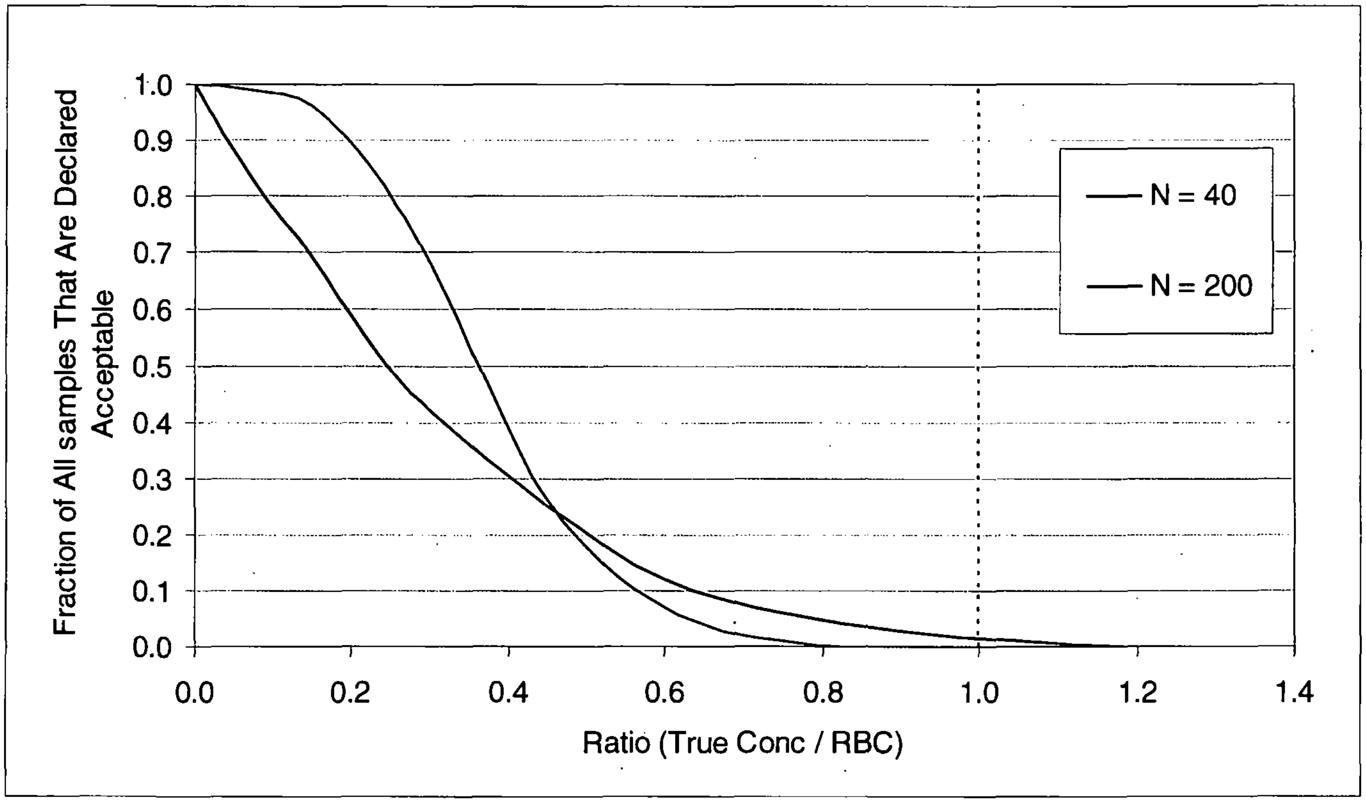

Figure 5-4
Mixed ACM
(CAB, Roofing, AirCell)
(IRIS Risk Model)

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5.2.4 MODIFIED STRATEGY FOR DECISION-MAKING

In accordance with standard EPA guidance at Superfund sites (e.g., EPA 2001), it is expected that the size of most decision units at the NRE site would range from about ¼ to ½ acre. Based on this, the total number of decision units in the NRE development requiring evaluation would likely be at least 350, and potentially 400-500. Thus, implementation of the sampling-based procedure for decision-making described above would require a minimum sampling effort of at least 7,000 surface soil samples and at least 39,000 subsurface borings, and the actual number might be higher. EPA believes that this effort would be impractical and that in most cases, even with this extreme effort, it would not be possible to declare an area clean (95% confidence level that cumulative risk is less than 1E-04) unless zero contamination is seen at each step. This problem would become much more severe for lower target risk values (e.g., the State of Oregon has a default target risk of 1E-06) or if alternative asbestos risk models being evaluated by EPA were employed (e.g., EPA 2003).

Therefore, EPA has devised an alternative strategy for characterizing the risk from asbestos contamination present at each parcel of the site. This strategy is based on the assignment of site areas to three different categories ("bins"), as follows:

- **Bin A** – Areas assigned to Bin A are characterized by the past or present occurrence of ACM on the surface, or the occurrence of former base buildings that are no longer present. In these areas, it is expected that ACM will always be present in the surface and/or subsurface soil as a result of ACM being dispersed during building demolition, and that it will not be possible to exclude any area from concern based on any plausible sampling strategy. Therefore, all locations assigned to Bin A will be presumed to pose an unacceptable health risk from exposure to asbestos, based on a presumed likely future residential land use, and all Bin A areas will be identified for remediation.
- **Bin B** – Areas assigned to Bin B are characterized by the occurrence of visible ACM or building debris at the surface, but it is believed that no former base buildings existed near the location, and that the ACM material was likely placed at the location by hauling. In this case, it is likely that the lateral and vertical extent of contamination is much more limited than for Bin A areas, and that it will be possible to design location-specific sampling strategies to define the area (and perhaps the depth) of contamination. Once defined, all areas of ACM contamination will be identified for remediation, while areas outside the contaminated area will be considered acceptable.
- **Bin C** – Areas assigned to Bin C are areas where no ACM or building debris has been observed, no base buildings that were demolished are known to have existed in the area, and no reason exists to suspect placement of ACM waste in the area. All such areas will be verified by visual inspection and limited sampling, as needed, to guard against potential mis-classification. All locations confirmed as Bin C will be considered to have acceptable risk without further sampling or remediation.

5.3 SITE EVALUATION APPROACH

Investigation activities conducted at each property will be dependent on the parcel contamination classification. Investigations at Bin A and Bin B properties will be conducted to determine the area or amount of material that will require remedial actions. Actions will be conducted at Bin C properties to determine if they were properly classified. Table 5-4 summarizes the types of investigative activities that will be completed at each property and how information collected from that activity will be used.

Table 5-4. Summary of Investigation Activities

Parcel Contamination Classification	Investigative Activities	Use of Information
Bin A	Burial Pile Investigations	Determine the vertical and lateral extent of material that would require removal down to grade.
	Remedial Boundary Investigations	Determine the lateral boundary to which remedial actions will be completed.
	Surficial Visual Inspection	Determine the locations of the burial piles that require investigation.
Bin B	Burial Pile Investigations	Determine the vertical and lateral extent of material that would require removal down to grade.
	Surficial Visual Inspection	Determine the locations of the burial piles that require investigation.
	Remedial Boundary Investigations	Determine the lateral boundary to which remedial actions will be completed.
Bin C	Surficial Visual Inspection	Determine if the property was misclassified, and if ACM remediation or additional investigations are required. If ACM is observed, the property will be reclassified to Bin B. If ACM is not observed, the property will remain classified as a Bin C property.
	Bulk Soil Sampling	Determine if free asbestos fibers are present in areas where ACM is not observed.

It is assumed that a home interior cleaning will be conducted at any vacated property before it is reoccupied, so indoor characterization activities likely will not be conducted at the vacated properties in the near term.

Section 9.2 provides additional details regarding the implementation of these activities.

5.4 DATA QUALITY OBJECTIVES

The primary purposes for conducting the activities described in Section 5.2 are to:

- Determine the volume of ACM-containing burial piles that exists above grade at Bin A and Bin B properties.
- Determine the lateral extent of areas requiring remediation at Bin A properties when the property boundary is not adjacent to another area to be remediated.
- Determine the lateral extent of hot spot areas requiring remediation at Bin B properties.
- Determine if free asbestos fibers are present in soil at Bin C properties where ACM has not historically been observed or is currently present at the surface.
- Determine if Bin C properties were classified correctly.

6. RI INVESTIGATIONS AT OCCUPIED PARCELS

As indicated earlier, it is expected that four homes within the footprint of the former base at NRE will remain occupied after the remaining properties are vacated under the settlement (Figure 6-1). As part of the RI, characterization activities will be conducted to determine if current indoor and outdoor risks are above a level of concern that would trigger a time-critical response action. Possible response actions will be determined prior to conducting the investigation activities.

6.1 RISK EVALUATION/CHARACTERIZATION APPROACH

In order to determine if asbestos poses a current risk to the remaining residents a characterization approach will be implemented to estimate risk from asbestos that may be present in indoor air, indoor dust and outdoor soils. Once data are collected, EPA will use the data to determine if site conditions pose an unacceptable risk to the remaining residents.

6.1.1 Evaluation of Risk from Indoor Dust

Once indoor dust becomes contaminated with asbestos, it may pose a risk if the dust is disturbed, becomes airborne, and is inhaled by residents. Sampling of indoor dust will be conducted at homes of remaining residents to evaluate the potential for this risk pathway. Participation in this sampling event is strictly voluntary; residents will be contacted in advance to explain the sampling program and to determine if they want to participate in this sampling event. If residents at occupied homes do not wish to participate in the sampling event, it may be deemed necessary to conduct sampling in unoccupied homes. Specifics regarding sampling methods and analytical methods will be discussed in a site-specific SAP developed by EPA.

6.1.2 Evaluation of Risk from Indoor Air

Indoor air samples will also be collected at homes where residents will remain. Sampling will consist of collecting stationary air samples and may also include the collection of personal air samples. Participation in this sampling event is strictly voluntary and residents will be contacted in advance to explain the sampling program and determine if they want to participate in this sampling event. If residents at occupied homes do not wish to participate in the sampling event it may be deemed necessary to conduct sampling in unoccupied homes. Specifics regarding sampling methods and analytical methods will be discussed in a site-specific SAP developed by EPA.

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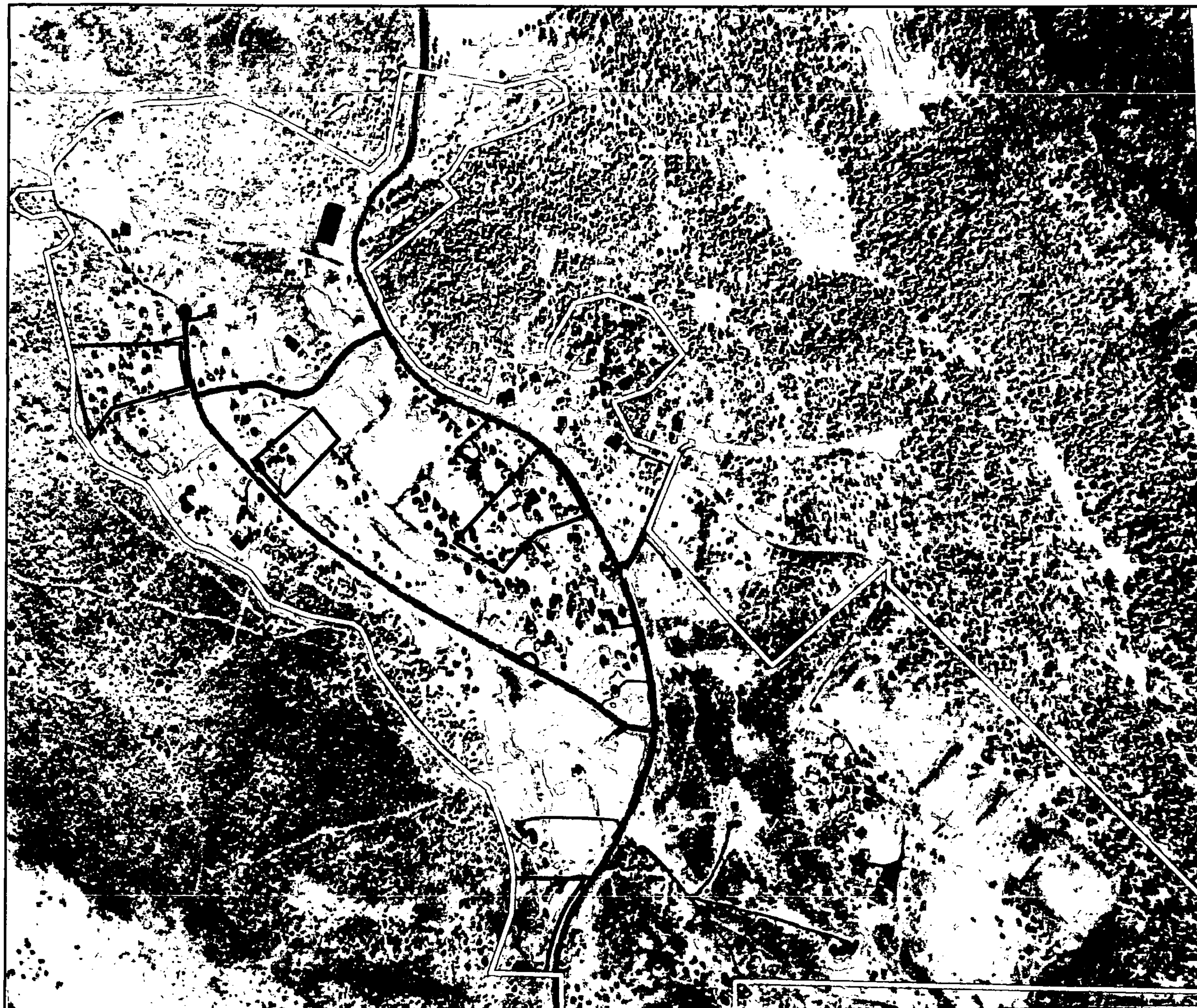

Figure 6-1
Occupied Parcels west of Old Fort Road, expected after June 2006

Legend

Site Boundary

Occupied Parcels

N

0 0.1 0.2
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

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6.1.3 Evaluation of Risk from Outdoor Soils

Inhalation of asbestos fibers may occur if outdoor soils containing asbestos are disturbed by the residents' activities. The release of asbestos from soil into outdoor air is highly variable, depending on the nature and intensity of the soil disturbance, the presence or absence of visible ACM and free asbestos fiber in the soil, as well as the condition of the soil (wet vs. dry, lawn-covered vs. bare). To evaluate the potential risk at NRE from asbestos in soils, activity-based sampling will be conducted at each occupied property. The details for activity-based sampling will be presented in a site-specific SAP developed by EPA.

During a site reconnaissance conducted in spring of 2006, EPA and other stakeholders will determine the locations where activity-based sampling will be completed. One objective will be to complete activity-based sampling in an area where AirCell and MAG are located. This may require establishing activity-based sampling locations on properties that are not currently occupied. If the locations chosen for activity-based sampling are at properties that remain occupied, the resident will be contacted in advance to explain the sampling program and determine if they want to participate in this sampling event.

6.2 DATA QUALITY OBJECTIVES

The primary purpose for conducting the activities described above is to determine if asbestos poses an unacceptable risk to residents who will remain at NRE. Information to make this determination will be collected as described in Section 6.1 and will include both indoor and outdoor characterizations. Acceptable target concentrations will be presented in the SAP.

The decisions to be made from the information collected in these activities are to:

- Determine if the concentration of asbestos in indoor dust exceeds an acceptable target concentration.
- Determine if the concentration of asbestos in indoor air exceeds an acceptable target concentration under normal living conditions.
- Determine if airborne concentrations of asbestos generated during soil-disturbing activities exceed an acceptable target concentration.

If indoor dust or airborne asbestos concentrations exceed acceptable target levels, EPA may conduct interim actions to conduct interior cleanings at homes where residents remain. If outdoor soil asbestos concentrations exceed the acceptable target levels, EPA will likely suggest that residents limit disturbing soils until future remedial actions are identified and completed.

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7. LARGE LAND UNIT CHARACTERIZATION

Four large land units exist at the site that will require further characterization to determine potential remedial actions: the former landfill, wastewater treatment clarifiers, the former swimming pool, and a suspected burial pile at the former rifle range. These units are described in more detail in Section 9.2.3 and are pictured in Figure 9-2.

The former landfill, former wastewater treatment clarifiers, and rifle range are classified as Bin B properties because ACM has been observed at these locations but MRB structures were not present at these properties during operation of the MRB. The property containing the former swimming pool is classified as a Bin A property because ACM has been observed and structures were present at the site during MRB operation.

The sections below describe the characterization approach that will be taken at the large land units. Further details will be included in a site-specific SAP.

7.1 CHARACTERIZATION APPROACH

The characterization approach implemented at the large land units will determine the quantity of ACM located in these areas and aid in determining necessary remedial actions for each of the areas. The large land units will be characterized using test pits and bulk soil sampling around the areas.

A series of test pits will be excavated where ACM is believed to be present in each of the areas. The test pits will be used to determine the amount of visible ACM present and, if possible, the depth to which visible ACM extends bgs. The purpose of excavating the test pits is to estimate the volume of material that may be present in the large land units. Soil/ACM quantities are needed to evaluate excavation and removal as a potential remedial method.

Because of the past practice of dumping and driving over friable ACM in the large land units at the site, it is conceivable that ACM and free asbestos fibers maybe present adjacent to the large land units. Bulk surface soil samples will be collected adjacent to the large land units to determine the boundary of the area requiring remediation. If ACM is found in surrounding areas, the remedial boundary will be extended. If free asbestos fibers are found at levels exceeding an acceptable target concentration, these soils will also be included in the remedial area.

Samples from the former landfill will include analysis for non-asbestos COPCs, as described in Section 8.

7.2 DATA QUALITY OBJECTIVES

The primary purpose for conducting the activities described above is to estimate the quantity of ACM and associated soil that may require remediation at the former landfill, wastewater treatment clarifiers, the former swimming pool, and a suspected burial pile at the former rifle range. Information to make this determination will be collected as described in Section 7.1 and will include test pits and surface soil samples.

The decision to be made from the information collected in these activities will be to determine the quantity of ACM that may require removal or the area requiring capping at each of the four large land units.

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8. NON-ACM COPC INVESTIGATION

8.1 CHARACTERIZATION AND RISK EVALUATION APPROACH

Given the uncertainties about the presence of non-ACM COPCs in various locations at the NRE site, a tiered approach will be taken to characterize areas and evaluate their risk. The following approach will be used:

1. **Initial Location Screening Step**: The objective of this step is to determine if COPCs are or are not present at levels justifying additional sampling and analysis. The analyses will be of a general nature, and samples will be archived, when possible, for more detailed analysis. For this step, areas of potential concern will be determined (summarized below), general type of sampling and analysis will be determined, the areas will be visited to determine the specifics for sampling, a SAP will be written, and field work will be conducted. For soil samples, analytical results will be compared against soil screening values to determine if contaminants are present and if any areas warrant additional investigation. For surface water samples collected in the former landfill area, if surface water is observed, any detected contaminants will be evaluated further.
2. **Focused Evaluation**: If any areas are determined to have COPCs at concentrations warranting further investigation and delineation, a second sampling event will be conducted at those areas. The purpose of this focused evaluation is to further characterize those areas of concern so sufficient information is obtained to perform a risk assessment for the areas and support FS analysis. For those areas more extensive sampling will be performed and contaminant-specific analyses done. Analytical results will initially be compared against DQO parameters specified below. Areas that have analytical values exceeding the DQO values will undergo a formal risk assessment.

Any risk assessment will follow EPA risk assessment guidance. For areas of concern determined to have current or potentially future unacceptable risk, an FS analysis will be completed that evaluates response actions, technologies, and process options to address risk created by the areas. Evaluation of remedial alternatives for the areas of concern will be combined into larger remedial action units and integrated into planned ACM remedial actions as appropriate to provide for a protective and cost-effective site-wide remedy.

8.2 DATA QUALITY OBJECTIVES

Method Detection Limits for sample analyses will be based on:

- **Carcinogens**: EPA Region 9 PRGs for the residential direct contact exposure pathway for soil samples.
- **Noncarcinogens**: PRGs multiplied by 0.10 for the residential direct exposure pathway for soil samples.
- **EPA Region 9 soil screening levels (SSLs)** for the migration to groundwater pathway (dilution attenuation factor of 20) for soil samples in areas where there is a potential threat to groundwater. The PRG and SSL will be compared and the lower value selected.
- **Oregon DEQ ecological risk screening values** for chemical exposure to birds and mammals for surface soil and water samples.

8.3 SITE EVALUATION APPROACH

Given the limited information available on the nature and extent of potential non-ACM contamination at the site, the investigation will be conducted in a step-wise manner. Each step will build on the information gained in previous steps to allow focusing the investigation tasks. The following steps will be taken to evaluate non-ACM COPCs at the site:

1. Existing documents will be reviewed to determine potential areas and contaminants of concern. The results of this review are summarized in Sections 3 and 4 of this RI/FS work plan.

2. Prior to developing a SAP, a site survey will be conducted to field-locate areas of concern. Sampling locations will be selected based on current and former building locations and suspected or known past practices. A combination of directed and random sample locations will be selected. A portion of the samples will be located at specific areas of interest. A portion of the samples will be located randomly within the areas of concern. This approach provides data at areas considered to have a higher probability of contamination, but allows for detection of contamination resulting from unknown conditions.

3. Areas that were previously investigated and had detectable concentrations, or where samples were not analyzed at sufficiently low concentrations, will be re-sampled or sampled more intensively. The previous investigations were noted above. Recommended resampling includes the following:

   - Based on sampling results at the firing range, additional investigation should be performed across the remainder of the rifle range for NBECs and metals and in the vicinity of the samples that contained elevated concentrations of lead and arsenic. These investigations will be performed by USACE through the FUDS program.

   - Based on previous lead-based paint investigations, it appears that there are few detected concentrations. Further investigation for lead may be considered in the vicinity of Lot 015D0-03200 where the samples were collected and removal work was previously completed.

   - Based on detection limits that were higher than PRGs, it is recommended that soil at the transformer sites be re-sampled.

4. A SAP will be prepared based on sample locations identified in Steps 2 and 3. Chemical analyses will be selected based on past practices and on analytical methods that provide sufficient resolution to allow for high confidence that the initial screening steps are sufficient to allow for accurate assessment of contaminants. Given the limited understanding of the past site conditions, analytical methods that detect a broad range of chemicals will be selected, when available. Table 8-1 below summarizes the general COPCs for the areas of concern.

5. Samples will be collected at the site and laboratory analyses completed as defined by the SAP. Sample collection, handling, shipping and storage will be in accordance with standard operating procedures (SOPs) included in the SAP to provide consistent sample quality.

6. Analytical results of the sampling will first be evaluated to see if there are any COPCs detected. If they are detected in soil, the analytical results will be compared against screening values (noted in the DQO section above) to determine if they are present at levels potentially causing risk. COPCs in surface water from seasonal

streams will be investigated further, possibly with sediment sampling and additional surface water sampling.

7. Based on the field observations and laboratory results, conceptual models will be developed for each area of concern. Elements of the conceptual models will include the nature and extent of the contaminants, potential migration pathways, and potential receptors.
8. For areas where the nature and extent of contamination is adequately understood to meet the characterization objectives, additional studies will be developed to fill data gaps.
9. Additional investigations and studies will be conducted as needed to meet the characterization objectives.

Table 8-1. Contaminants of Potential Concern at Specific Areas On Site

Area of Concern	Contaminants of Potential Concern
Rifle range	Lead and other metals and/or small rocket propellant in surface, near-surface, and deeper soils
Central power plant	VOCs in deeper soils; and/or TPH and/or PCBs in surface, near-surface, and deeper soils; PAHs in surface and near-surface soils
Known or suspected burial pits	VOCs in deeper soils; and/or SVOCs, TPH, PCBs, pesticides, and/or metals in surface, near-surface, and deeper soils
Maintenance/repair shop	VOCs in deeper soils; and/or TPH and/or metals in surface, near-surface, and deeper soils
Laundry	VOCs in deeper soils; and/or SVOCs in surface, near-surface, and deeper soils
Possible landfill	VOCs in deeper soils; and/or SVOCs, TPH, PCBs, pesticides, and/or metals in surface, near-surface, and deeper soils
Service station	VOCs in deeper soils; and/or SVOCs, TPH, PCBs, pesticides, and/or metals in surface, near-surface, and deeper soils
Fire station	Petroleum fuels and/or motor oil in surface, near-surface, and deeper soils
Water seep from disposal area near warehouse and landfill	VOCs and/or SVOCs, TPH, PCBs, pesticides, and/or metals in seep water
All buildings - lead-based paint	Lead in surface, near-surface, and deeper soils

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9. REMEDIAL INVESTIGATION TASKS

9.1 GENERAL RI ACTIVITIES

Prior to initiating site activities, documents providing detailed field methods and procedures will be created. A site health and safety plan (HASP) will be developed; this plan will govern all health and safety procedures at the site for the duration of the RI. A site-specific SAP consisting of two parts, the quality assurance project plan (QAPP) and FSP, will also be generated for work related to the RI. Sections 9.1.1, 9.1.2, and 9.1.3 describe the elements that will be included in the HASP, QAPP, and FSP, respectively.

9.1.1 Health and Safety Plan

A site-specific HASP will be generated for the RI field investigation activities. The HASP will be prepared, at a minimum, in accordance with the requirements of 29 Code of Federal Regulations (CFR) 1910.120 and 29 CFR 1926. The site-specific HASP will address, at a minimum, the following:

- Names of key personnel and alternates responsible for the implementation and maintenance of the HASP. Describe these personnel and the lines of communication to be followed in performance of site work.

- A health and safety risk analysis for each anticipated site task and operation. This will include a discussion of the materials thought to be on site and their health and safety hazard potentials. Also to be included is a discussion concerning the types of equipment and physical hazards associated with the operation of equipment that will be required to perform the site work.

- Site-specific health and safety training that will be provided to all employees participating in site work. This training will include, at a minimum, the requirements of the HASP, respiratory protection awareness, and asbestos awareness.

- Initial personal protective equipment (PPE) requirements specified for each anticipated site task and operation. This equipment will be prescribed based on materials suspected of being on site and the activities associated with these materials.

- Medical surveillance requirements.

- The types and frequencies of both personal and environmental air quality sampling, defined by specific, anticipated site tasks and operations. Specifics as to the types of equipment, sampling and analytical methodologies, and sampling equipment operation, calibration, and maintenance, will be provided.

- Details as to site control measures. This will include site delineation, procedures for site entry and exit, the use of a "buddy system" for site communications, site-specific safe work practices, and the identification of the nearest medical assistance.

- Site-specific equipment and personnel decontamination procedures. These procedures will be protective of personnel health and prevent sample cross-contamination.

- Standard operating procedures that are specific to the site.
- A contingency plan, to be implemented in the event of injury, illness, fires, etc. The contingency plan will meet the requirements of 29 CFR 1910.120(l)(1) and (l)(2).
- Confined space entry procedures, as necessary.
- Site excavation guidelines, where required.

All site personnel will be required to review and sign the HASP before being allowed to perform work at the site. The original site-specific HASP, which will include original signatures of all site workers, will be stored at the field office. An additional copy will be carried in each vehicle used during field activities.

9.1.2 Field Sampling Plan

A site-specific FSP will be developed to provide details regarding field procedures, including sample collection procedures and sample custody procedures. Established and approved SOPs detailing field procedures will be included in the plan. The purpose of the FSP is to provide guidance to ensure that all environmentally related data collection procedures and measurements are scientifically sound and of known, acceptable, and documented quality and that they are conducted in accordance with requirements of the project.

As described in *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988), the FSP will contain the following information:

- Site background
- Sampling objectives
- Sample location and frequency
- Sample designation
- Sampling equipment and procedures
- Sample handling and analysis

9.1.3 Quality Assurance Project Plan

A site specific QAPP will be developed in accordance with *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5) and the *Guidance for Quality Assurance Project Plans* (EPA QA/G-5). In addition, DQOs will be developed in accordance with the *Guidance for the Data Quality Objectives Process* (EPA QA/G-4).

As described in EPA QA/R-5, the QAPP will describe the policy, organization, functional activities, and quality assurance/quality control protocols necessary to achieve the project DQOs. These fundamentals of the QAPP should be incorporated into the following 15 elements:

- Project description
- Problem organization and responsibilities
- QA objectives for measurement

- Sampling procedures
- Sample custody
- Calibration procedures
- Analytical procedures
- Sampling methods
- Data reduction, validation, and reporting
- Internal quality control
- Performance and system audits
- Preventative maintenance
- Data assessment procedures.
- Corrective actions
- Quality assurance reports

Work will not begin at the site until all decision makers and data users have reviewed and approved the contents of the QAPP. In addition, all contractor personnel must review and understand the contents of the QAPP before performing work at the site.

9.1.4 Sampling and Analysis Plan

Three site-specific SAPs will be developed for the site, one for each of the following investigation efforts:

- RI activities at occupied properties – including indoor personal air, indoor stationary air, indoor dust, and activity-based sampling.
- Remedial design and RI activities related to ACM/asbestos – including burial pile investigations, remedial boundary investigations, surficial visual inspections, bulk soil sampling, and large land unit investigations.
- RI activities related to non-asbestos COPCs.

In order to incorporate required elements of the FSP and QAPP and reduce duplication of information, the format of each SAP will provide details required for both the FSP and QAPP in the following format:

Section 1: Introduction – This section will include project objectives, schedule and deliverables, and project organization, including an organization chart showing lines of communication. This section will also define roles and responsibilities, and identify data users and decision makers.

Section 2: Site Background – This section will include information regarding site location, history, environmental setting, and contaminants of concern. The specific site problems to be resolved by the RI will also be defined in this section.

Section 3: Data Quality Objectives – This section will include DQOs developed for the site in accordance with EPA guidance QA/G-4, and will describe how results obtained from the RI will be reconciled with the requirements defined by the data users and decision makers.

Section 4: Sampling Program, Rationale, and Locations – This section will include information on sampling locations, rationale for the sampling program (including sample types and numbers), and details regarding sample analysis and data validation.

Section 5: Field Activity Method and Procedures – This section will detail field activities and sampling procedures, including procedures and requirements related to the following:

- field sample custody and documentation
- sample labeling and identification
- chain-of-custody
- sample packaging and shipping
- field paperwork distribution
- equipment decontamination
- handling of investigation-derived waste
- health and safety monitoring
- training administration and documentation
- assign responsibilities for ensuring that the most recent and approved versions of all field documents are distributed to site personnel
- assign responsibilities for preparing and distributing reports to project decision makers and data users
- selection of preparation methods, sample volumes, sample containers, and holding times
- procedures and methods will be described or applicable SOPs will be referenced
- inspection of supplies and consumables

Section 6: Laboratory Analysis Requirements – This section will detail laboratory analysis requirements and will include details related to the following topics:

- analytical methods
- reporting limits
- holding times
- laboratory custody procedures and documentation
- laboratory quality assurance program
- documentation and records
- data management
- tracking the path of data from their generation in the field or laboratory to their final use or storage
- description of information required for both hard copy and electronic analytical data reports

Section 7: Quality Assurance/Quality Control Program – This section will include details of the RI QA/QC program, including:

- procedures to be used for verification and validation
- description of assessment activities, including frequency
- procedures for resolution of issues discovered during quality assessments
- identification of the types of data needed for project implementation or decision making that are obtained from non-direct measurement sources
- intended use and any acceptance criteria for quality assessments
- procedures and frequency of equipment calibration and maintenance

Section 8: References

Appendices – These will include copies of all field forms, SOPs, guidance documents, and the HASP.

9.2 CHARACTERIZATION

9.2.1 Parcel Classification Based on Asbestos

Figure 9-1 shows the current parcel contamination classification based on the bin system discussed in Section 5. Table 5-4 summarizes the investigation activities that will be conducted at the properties classified as Bin A, Bin B, and Bin C. The following sections summarize how the investigation activities presented in Table 5-4 will be implemented. Further detail will be provided in a site-specific SAP to be developed.

9.2.1.1 Investigation Activities at Bin A and Bin B Properties

The first investigation activity to be completed at Bin A and Bin B properties will be surficial visual inspections. The inspections will be conducted to determine the locations of any unnatural piles or mounds. The piles or mounds identified during the surficial visual inspections will be further investigated during burial pile inspections.

Burial pile inspections will include the excavation of test pits to determine the type of debris present. Field notes regarding the type of material encountered in the test pits will be recorded. If ACM is found in the burial piles, additional information regarding the condition of the pile will be collected, as well as the types of ACM observed. If piles or mounds of ACM are found to occur at Bin B properties, investigations to determine the boundary of the area requiring remediation will be conducted.

Remedial boundary investigations will be conducted at Bin B properties to determine the area surrounding a pile or mound that will be included in the remediated area. This inspection will be conducted by collecting bulk soil samples at some distance away from and surrounding the pile or mound. All cores will be visually inspected in the field to determine if visible ACM is present. If ACM or building debris is observed in the field sample, the remedial boundary will be expanded to include this area and an additional borehole will be advanced at some distance away to determine if the remedial boundary requires additional expansion. If ACM or building debris is not observed, then it will be assumed the remedial boundary will not be expanded. All cores will be stored for possible future analysis, and a 10 percent subset of cores that do not contain visual ACM will be analyzed via PLM by a modified Golloway Protocol. The Golloway Protocol is a site-specific PLM method. It is used for the analysis of soil samples to determine the presence of bulk ACM and free asbestos fibers in soils through the analysis of small aliquot samples.

Similar remedial boundary investigations will be conducted at Bin A properties. The investigations will be implemented using the same field sampling procedures and analysis as described above, but will be conducted near property boundaries that are not adjacent to another area to be remediated. For instance, the areas where Bin A property boundaries share the western boundary of the site will be investigated to determine the remedial boundary.

9.2.1.2 Investigation Activities at Bin C Properties

Investigation activities at Bin C properties will include surficial visual inspections and the collection of bulk soil samples. Surficial visual inspections conducted at Bin C properties will consist of personnel walking each property in a systematic fashion to determine if ACM is observed on the surface. If ACM or building debris is discovered, the property will be reclassified as Bin B and additional investigation activities will be conducted as described in Section 9.2.1.1 to determine the extent of ACM present.

Bulk soil samples will also be collected at Bin C properties. Each sample will be collected from the surface to approximately 2.5 feet bgs and analyzed separately for the presence of visual ACM and free asbestos fibers.

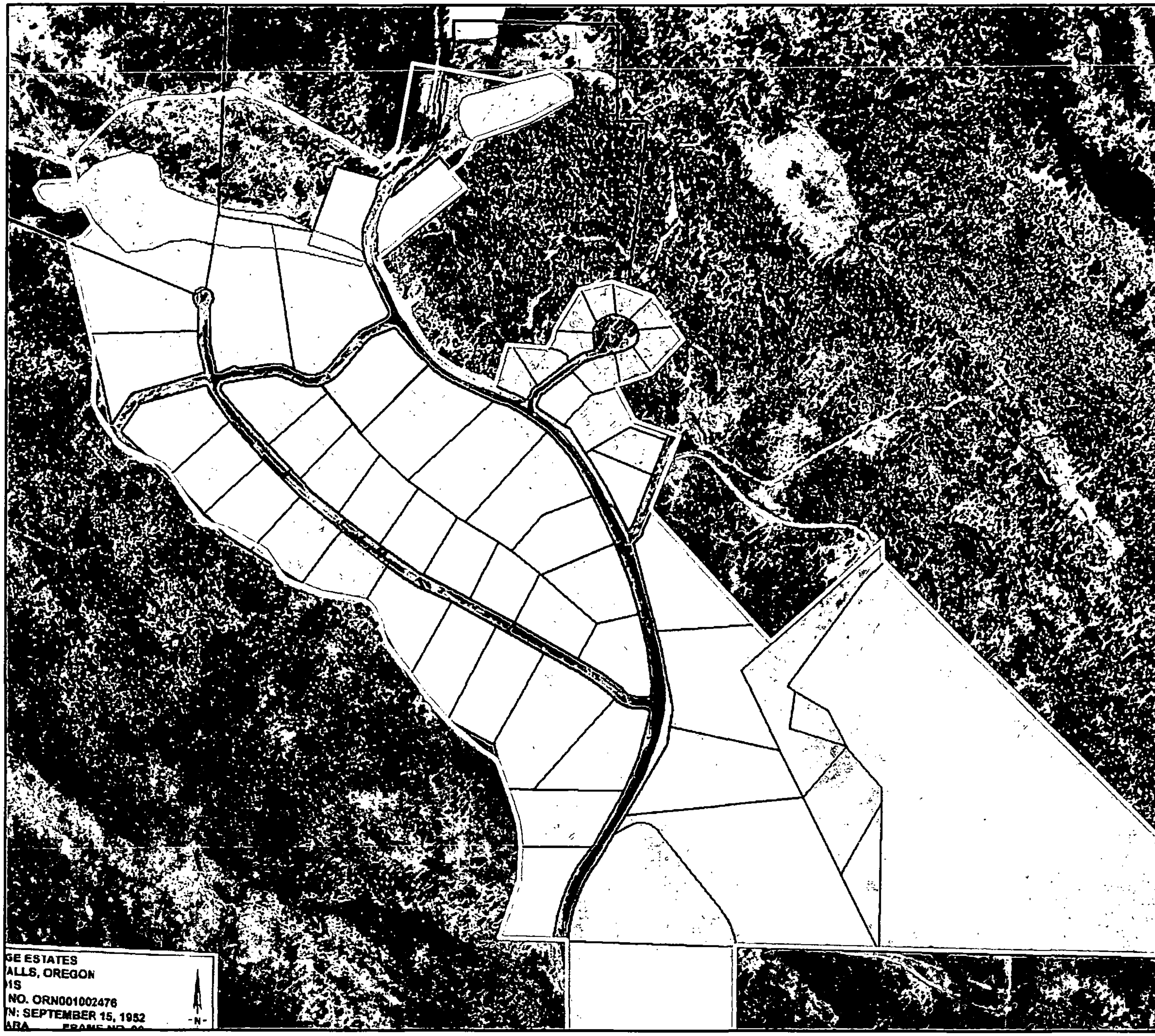

Figure 9-1
Initial Parcel Contamination Classification

Legend

- Bin A
- Bin B
- Bin C

N

0 0.1 0.2
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

Contact Information:
Parametrix
700 NE Multnomah
Suite 1000
Portland, OR 97232-2131
(503) 233-2400

April 2006

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Parametrix

Analysis by H.Gilbert; Analysis Date: 11-04-2006; Plot Date: 11-04-2006; File Name: Fig9-1_ParcelContaminationClassification.mxd

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9.2.2 Investigation Activities at Occupied Properties

For the purpose of determining if current exposures to asbestos pose a risk to remaining residents, characterization activities will include investigation of possible exposure to asbestos both from indoor and outdoor sources. A SAP will be developed by EPA to include specific procedures to be conducted at the site to complete measurements at occupied properties.

Indoor asbestos exposures will be characterized by the collection of indoor dust, indoor personal air, and indoor stationary air samples. Dust samples will be collected from each floor used as living space (i.e., ground floor, second floor, finished basement) in accordance with ASTM D5755-95 (1995) and the site-specific procedures defined in the site-specific SAP.

Indoor air samples will be collected during routine household activities to determine if asbestos fibers are present in indoor ambient air during normal living conditions.

Outdoor exposures will be characterized by performing activity-based sampling, including the collection of bulk soil samples. In activity-based sampling, three standardized activities (also know as scenarios) that cause soil to be disturbed and asbestos fibers released to the air will be conducted. All activities will be conducted by adult "actors" wearing appropriate PPE, including respiratory protection. Because of the variability of soil conditions, presence of ACM, and vegetative cover conditions, each scenario will be conducted multiple times at different locations.

9.2.3 Investigation Activities at Large Land Units

Area-specific ACM investigations will be used to characterize four large land areas identified at the site: the area referred to as the ravine or former landfill, the filled in clarifiers at the former waste water treatment plant, the filled in former swimming pool, and the former rifle range. Figure 9-2 shows the location of these land units.

Characterization of the large land units for ACM will include excavation of test pits and remedial boundary investigations. Test pits will be excavated to the maximum depth a mini-excavator can reach (10 feet) or to native soil, whichever comes first. In the case of the swimming pool and clarifiers, excavation will stop if the bottom of the structure encountered before a depth of 10 feet is reached. The proposed test pit locations will be based on the original configuration of large areas in historical aerial photographs and the observed locations of disturbed soils and mounds. Test pits will be used to collect observations of the types and approximate quantities of ACM present. Soil samples for asbestos will not be collected from the test pits, because it is assumed that if removal is the chosen remedial option, soils associated with ACM will be removed regardless of the presence of free asbestos fibers.

Remedial boundary investigations will be conducted in a manner similar to those conducted for Bin A and Bin B. This inspection will be conducted by collecting bulk soil samples from boreholes collected from a grid system surrounding the land unit. All cores will be visually inspected in the field to determine if visible ACM is present. If ACM or building debris is observed in the field sample, the remedial boundary will be expanded to include this area and an additional borehole will be advanced at some distance away to determine if the remedial boundary requires additional expansion. If ACM or building debris is not observed, then it will be assumed the remedial boundary will not be expanded. All cores will be stored for possible future analysis, and a 10 percent subset of cores that not contain visual ACM will be analyzed via PLM by a modified Golloway Protocol.

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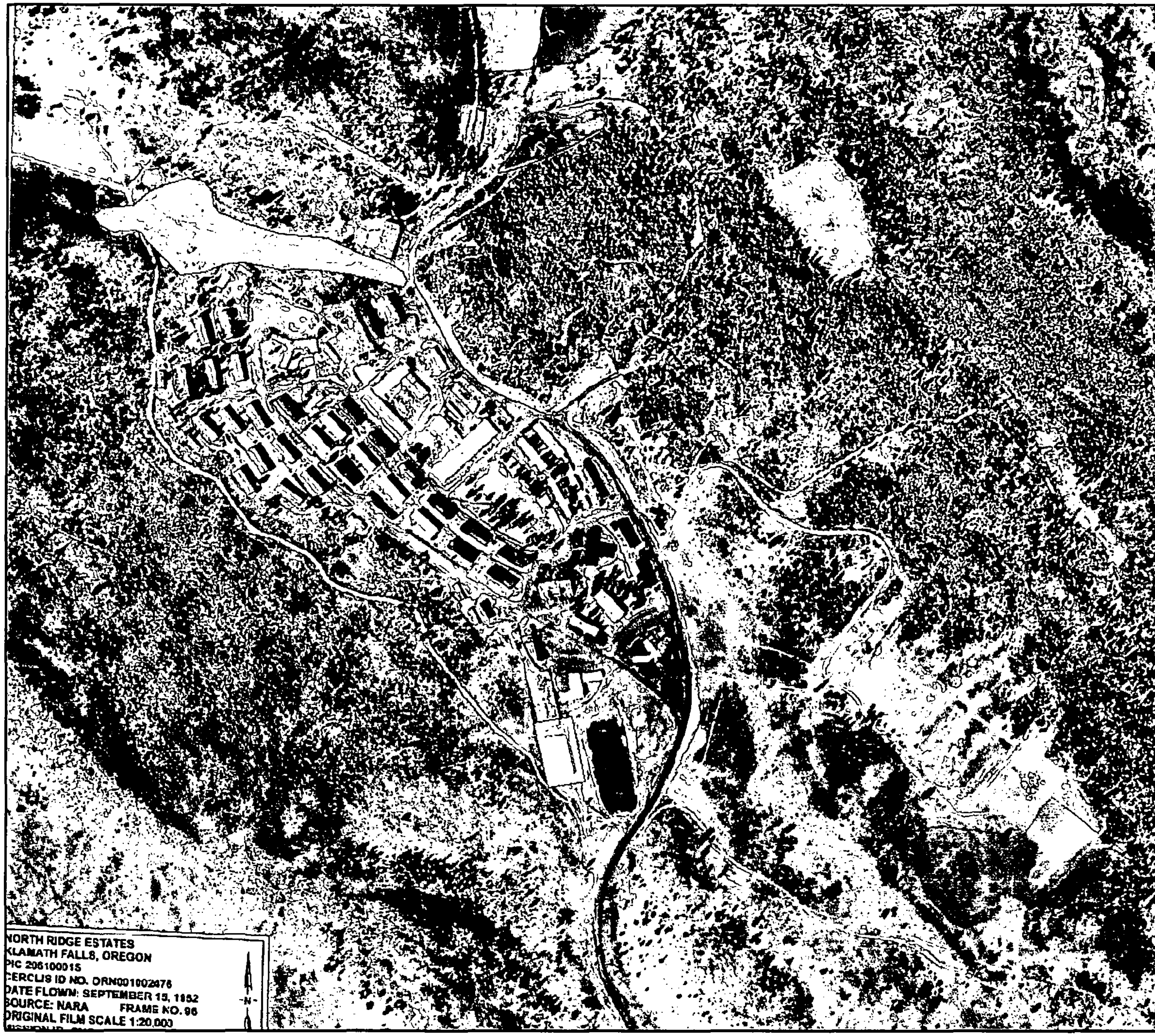

Figure 9-2
North Ridge Estates
Large Land Units

Legend

- Former Rifle Range
- Ravine (Former Landfill)
- Swimming Pool
- Wastewater Treatment Plant Clarifiers

N

0 0.1 0.2
Miles

Geographic Data Standards:
Projected Coordinate System:
NAD 1983 State Plane Oregon South FIPS

Data Source(s):
September 1952 Aerial Photo

Contact Information:
Parametrix
700 NE Multnomah
Suite 1000
Portland, OR 97232-2131
(503) 233-2400

February 2006

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Parametrix

Analysis by H.Gilbert; Analysis Date: 13-02-2006; Plot Date: 17-02-2006; File Name: Fig9-2_NorthRidgeEstatesLargeLandUnits.mxd

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9.2.4 Non-ACM COPC Characterization

Table 8-1 shows the areas to be investigated and COPCs for each area. Details of the sampling for each area will be developed following a site reconnaissance survey planned for mid-spring 2006. During the reconnaissance, all survey areas will be visited and foundations compared against historical photos and drawings to determine potential locations where disposal or release of material may have occurred. Sampling equipment and depths will be determined from the site reconnaissance and each location's potential COPCs.

9.3 REMEDIAL INVESTIGATION REPORT

Once field activities have been completed and data compiled, an RI report will be prepared in accordance with the outline suggested in the *Guidance for Conducting Remedial Investigations and Feasibility Studies under CERCLA* (EPA 1988):

Section 1: Introduction – This section will include the purpose of the report; the site background, including site description, site history, and information regarding previous investigations; and the report organization.

Section 2: Study Area Investigation – This section will include details of all field activities associated with site characterization.

Section 3: Physical Characteristics of the Study Area – This section will discuss the physical setting of the site, including:

- Surface Features
- Meteorology
- Surface-Water Hydrology
- Geology
- Soils
- Hydrogeology
- Demography and Land Uses
- Ecology

Section 4: Nature and Extent of Contamination – This section will present the data evaluation methodology and the results of site characterization, both natural and chemical components and contamination in media of concern at the site: soil, air, dust, surface water.

Section 5: Contaminant Fate and Transport – This section will present potential routes of migration at the site, describe contaminant characteristics and chemical persistence in the study area environment, and discuss factors affecting contaminant migration for all media of concern.

Section 6: Baseline Risk Assessment – This section will include a human health evaluation consisting of exposure assessment, toxicity assessment, and risk characterization. Note that the risk evaluation will be based on data collected as part of the 2006 field investigation. Risk information from prior investigations at the site will be summarized and incorporated into this risk assessment as appropriate.

Section 7: Summary and Conclusions – This section will present a summary of the nature and extent of contaminants at the site, site specifics for the fate and transport of contaminants, and a summary of the risk assessment. In addition conclusions related to data limitations, recommendations for future work, and recommended RAOs will be presented in this section.

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10. FEASIBILITY STUDY TASKS

10.1 OVERVIEW OF THE FEASIBILITY STUDY DEVELOPMENT PROCESS

The FS Report will be developed in a series of steps. All steps will be consistent with guidance on the RI/FS process and development of the work plan, as described in *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*, Interim Final (Office of Solid Waste and Emergency Response [OSWER] Directive 9355.3-01, October 1988). The guidance recommends concurrent development of the RI and FS as much as possible to ensure that the RI obtains information relevant to the development of remedial alternatives.

The initial consideration of remedial alternatives for the site began during the development of this RI/FS work plan. During the work plan development, preliminary technologies and alternatives development and screening were performed to help identify data needed for analysis that could be incorporated into the RI/FS work plan. Preliminary cost estimates for a few potential remedial alternatives were also prepared to enable an early identification of parameters which may be significant in affecting costs for asbestos remediation. This information will be used to ensure that adequate data is collected on relevant cost parameters for remedial alternatives.

Following the completion of the 2006 sampling event and evaluation of the results, the preliminary alternatives development will be updated based on new knowledge and information gained from the additional site investigation and risk analysis. If data is sufficient to allow, a more formal remedial alternative screening and development process will be used to refine the likely alternatives and technologies for final analysis.

The remedial alternative screening process will incorporate the initial steps from an FS, including identification of critical assumptions, development of preliminary remedial action objectives (RAOs), preliminary applicable or relevant and appropriate requirements (ARARs) analysis, identification and screening of technologies, development of alternatives, and preliminary cost analysis. The cost development will be of a general nature, intended primarily to identify the critical cost drivers that will influence total remedy cost and that are worthy of efforts to resolve uncertainties. Screening procedures are outlined in the National Contingency Plan (NCP), 40 CFR Part 300 and the *Guidance for Conducting Remedial Investigations and Feasibility Studies Under CERCLA*. Alternatives for both asbestos and non-asbestos containing material will be developed and screened, then the remaining combined alternative concepts will be developed to allow for a more careful development of costs. Costs for the remaining alternatives will be developed.

A number of asbestos alternatives will be identified for screening, including a No Action alternative, an institutional controls (ICs) alternative, a containment (on-site disposal) alternative, a removal and containment (onsite disposal) alternative, a removal and containment (off-site disposal) alternative, and one or two alternatives that contain combinations of the above. Based on current understanding of current technologies for asbestos, treatment alternatives for asbestos will likely not be developed in the FS. A list of alternatives similar to the asbestos list above will be considered for non-ACM COPCs, but it is less likely that on-site containment will be considered and more likely that forms of treatment will be evaluated.

Once all alternatives are developed they will be screened and combined to form site-wide alternatives. Alternatives will be developed for both asbestos and non-asbestos material, and will be combined into full alternatives for final evaluation to enable full site actions to be evaluated. Attributes and performance of the full set of alternatives will be defined, including ARARs attainment, residual risk, and cost.

The evaluation of alternatives will include an individual evaluation in which the performance or attributes of each alternative are described with regard to the specific evaluation criteria, and a combined evaluation where the alternatives are compared.

The FS Report itself will include a front section that will provide all steps required by the NCP, followed by appendices that contain more detailed technical information that supports the text, including detailed cost estimates and any needed technical memoranda on specific subjects.

10.2 REMEDIAL ALTERNATIVE DEVELOPMENT PROCESS

In the FS, combinations of technologies identified for their ability to treat the asbestos and non-asbestos COPC contamination at NRE will be assembled into alternatives for site-wide remediation. This process is summarized in the following steps:

- Identification of RAOs
- Development of response actions for each waste medium
- Identification and screening of technologies for site-wide technical implementability
- Identification and screening of technology process options for effectiveness, implementability, and cost
- Development of alternatives from the screened process options

RAOs are specific goals for protecting human health and the environment based on COCs, exposure routes, and receptors at a site. Under RAOs, PRGs – which are quantitative acceptable levels or a range of levels for COCs – are developed for each exposure pathway identified in the site risk assessments. The PRGS are based on levels outlined in ARARs from both federal and state agencies. PRGs will be developed during completion of the RI.

Response actions such as treatment, containment, excavation, extraction, disposal, or institutional actions are then developed to meet the RAOs. Technology types and process options that fall under each response action are then identified and screened for technical implementability. This is a general screening to eliminate options that cannot be implemented due to site-wide conditions identified in the RI. For example, on sites with contaminated groundwater in deep aquifers, technologies that can only treat groundwater at shallow depths are not implementable.

Technology types and process options that are technically implementable are then screened for effectiveness, implementability, and cost. These are broad screening criteria applied to how the technology or process option meets the response action it represents; they are therefore more focused on effectiveness than the implementability and cost evaluations.

Each of these steps in the development of potential remedial action remedies for NRE is presented below.

10.3 REMEDIAL ACTION OBJECTIVES

According to the NCP (40 CFR 300.430(a)(1)(I)), the goal of the remedy selection process is to select remedies that are protective of human health and the environment, that maintain protection over time, and that minimize untreated waste. RAOs are specific goals for protecting human health and the environment based on COCs, exposure routes, and receptors at a site. The preliminary RAOs for NRE are presented below.

- Prevent human exposure to airborne asbestos fibers.
- Prevent asbestos containing materials in soil from reaching the ground surface.

The RAOs will be finalized during the FS and will be based on the established ARARs, criteria, or limitations of the State of Oregon and federal laws in effect during and at the completion of the remedial action.

PRGs defining the action levels for cleanup of asbestos contaminated material required to meet these RAOs will be developed during completion of the RI activities at NRE.

10.4 RESPONSE ACTIONS

Response actions represent broad groups of actions that typically encompass a number of different technologies that form the basis of remedial alternatives that will satisfy the RAOs. These actions may include treatment, containment, excavation, extraction, disposal, institutional actions, or a combination of these. Like RAOs, response actions are media-specific.

Response actions selected for consideration at NRE will address potential asbestos contamination from demolished building materials left on or transported to applicable properties. The main human health pathway for asbestos exposure is through inhalation of asbestos fibers released from disturbance of this demolished building material in surface or near-surface soil. Numerous guidance documents prepared by both EPA and the Occupational Safety and Health Administration (OSHA) such as the Asbestos National Emission Standards for Hazardous Air Pollutants (NESHAP) Regulations (40 CFR 61, Subpart M) (EPA 1973) require either containment or removal of asbestos contaminated material as the only acceptable methods for exposure abatement. Thermal treatment technologies that mitigate asbestos exposure have been developed; however, they have not been demonstrated at large scale sites with varied soil matrices and are expensive to operate. Based on NESHAP and the lack of full-scale viable treatment technologies, the only applicable response actions for asbestos contamination at NRE are:

- No action
- ICs
- Containment
- Removal
- Transport
- Disposal
- Treatment

Each of these response actions is discussed in the following sections. Non-asbestos COPC response actions are also noted.

Institutional Controls

ICs provide protection against exposure through the use of non-engineered administrative or legal controls that limit land or resource use; they are considered a limited action remedial alternative. ICs can be a stand-alone remedy or can serve as a supplement to an engineering control remedial action throughout all stages of the cleanup process. The use of ICs as a sole remedy is not encouraged unless all other remedial actions are determined to be impractical. ICs are particularly beneficial when incorporated as a layered component of the cleanup process to provide overlapping assurances of protection from contamination.

Containment

Containment response actions are used to isolate the contaminated media and to restrict migration of contaminants. Containment can be accomplished through construction of a barrier to exposure or removal of the contaminated material. Since containment response actions do not have a treatment component, they do not reduce the concentration or volume of contaminants.

Removal

This involves the physical removal of contaminants from the area of interest. For soil, removal response actions would involve excavation of contaminated material. For non-asbestos COPCs, removal would depend on the nature of the contaminant. Contaminated soil is generally excavated, while contaminated water generally involves some form of hydraulic capture. Contaminants must be subsequently treated or disposed of before the risk of exposure is considered prevented.

Transport

For removed soil, transport would involve packaging and transportation likely by truck and/or rail of the removed materials. For surface water, transport would involve conveyance through a pipeline or capture in a containment vessel and transport by truck or rail.

Disposal

For removed soil, disposal would involve placement in an on-site location or off-site facility – typically a permitted landfill.

Treatment

Treatment is also a response action; although it is unlikely to be used for ACM due to technical impracticability. For non-asbestos COPCs, treatment of contaminated media is possible, followed by disposal of the treatment residuals and treated materials.

10.5 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

Quantitative cleanup levels that define the RAOs developed for a site are based on levels outlined in ARARs from both federal and state agencies. The NCP requires that the selected remedy for remedial actions must attain or exceed the ARARs in environmental and public health laws. It also requires that removal actions attain ARARs to the greatest extent practicable. The distinction between applicable and relevant and appropriate determines the constraints imposed on remedial alternatives by environmental regulations other than CERCLA.

Definition of ARARs

Section 121 (d) of CERCLA as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA) requires that remedial actions attain a degree of cleanup that ensures protection of human health and the environment. Section 121 (d)(2) of CERCLA, 42 U.S. Code (United States Code [USC]) Section 9621 (d)(2) limits federal ARARs to those federal environmental laws that set a standard, requirement, criterion, or limitation that is legally applicable or relevant and appropriate to those hazardous substances, pollutants, or contaminants that will remain on site following remediation.

For contaminants that will be transferred off site, Section 121 (d) of CERCLA requires that the transfer be to a facility that is operating in compliance with applicable federal and state laws. Section 121(d) of CERCLA, as amended by SARA, also requires attainment of

ARARs, including state environmental or facility siting laws, when the promulgated state requirements are more stringent than federal laws and are identified by the state in a timely manner. It should be noted that the NCP final rule states that potential state ARARs must be applicable to all remedial situations described in the requirement and not just to CERCLA sites.

In addition to ARARs, the NCP provides a list of federal non-promulgated criteria, advisories and guidance, and state standards to be considered (TBC). CERCLA also identifies limited circumstances in which ARARs could be waived.

Further discussions of applicable and relevant and appropriate requirements, TBC, and waivers are presented below.

Applicable Requirements

The NCP final rule for CERCLA defines applicable requirements as:

> "...those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal environmental or state environmental or facility siting law that specifically address a hazardous substance, pollutant, contaminant, remedial action, location or other circumstance found at a CERCLA site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be applicable."

State requirements are more stringent than federal requirements if the state program has federal authorization and the state requirements are at least as stringent. Applicable requirements must be met to the full extent required by law or waived by EPA.

Identification of ARARs is done on a site-specific basis and involves a two-part analysis: first, determining whether a given requirement is applicable, and second, determining if a requirement that is not applicable is both relevant and appropriate.

Relevant and Appropriate Requirements

If it is determined that a requirement is not applicable to a specific release, the requirement may still be relevant and appropriate to the circumstances of the release. The NCP final rule for CERCLA defines relevant or appropriate requirements as:

> "...those cleanup standards, standards of control, and other substantive environmental protection requirements, criteria, or limitations promulgated under federal or state law that, while not "applicable" to a hazardous substance, pollutant, contaminant, remedial action, location or circumstance at a CERCLA site, address problems or situations sufficiently similar to those encountered at the CERCLA site that their use is well suited to the particular site. Only those state standards that are identified by a state in a timely manner and that are more stringent than federal requirements may be relevant and appropriate."

Distinguishing a regulation that is relevant and appropriate is determined using best professional judgment, taking into account the purpose of the requirement. In some cases, a requirement may be relevant but not appropriate, given a site-specific circumstance. Therefore, such a requirement is not an ARAR for the site.

Other Requirements To Be Considered (TBC)

In addition to ARARs, TBC criteria are evaluated and utilized to determine the necessary level of cleanup for protection of human health or the environment. TBCs include nonpromulgated advisories, regulations, and guidance issued by federal or state governments that are not legally binding and are not generally enforceable but that may have specific bearing on all or part of the action. TBCs can be used to determine the necessary level of cleanup for protection of human health or the environment where no specific ARARs exist for a chemical or situation or where such ARARs are not sufficient to be protective.

Waivers

The Superfund law specifies situations under which the ARARs requirements may be waived (Section 121(d)(4)). The situations eligible for waivers include:

- Interim remedies
- Remedies in which attainment of the ARAR would pose a greater risk to human health or the environment than would non-attainment
- Technical impracticability of attainment
- Inconsistent application or enforcement of a state requirement
- Fund balancing (financial restriction within the Superfund program)
- Attainment of equivalent performance without the ARAR

Application of ARARs

ARARs are determined based upon an analysis of which requirements are applicable or relevant and appropriate to the distinctive set of circumstances and actions contemplated at a specific site. The NCP requires attainment of ARARs during the implementation of the remedial action, completion of the action, and when carrying out removal actions to the extent practicable.

For the ease of identification, ARARs can be divided into three categories: chemical-specific, location-specific, and action-specific, depending on whether the requirement is triggered by the presence or emission of a chemical, by a vulnerable or protected location, or by a particular action. These ARAR categories are briefly described below.

- Chemical-specific requirements are usually health risk or technology-based numerical values that may define acceptable exposure levels. These values establish the acceptable amount of concentration of a chemical that can be discharged or left in the ambient environment.
- Location-specific requirements relate to the site's geographic location relative to certain unique or protected areas, such as floodplains or wetlands, and may limit the scope of an action or place constraints on how it is implemented.
- Action-specific requirements are generally technology- or activity-based requirements that set controls on activities pertaining to a particular treatment or disposal method.

The preliminary federal and state ARARs for NRE are summarized by type in Table 10-1. Additional ARARs will be added as the project progresses, including chemical- and/or location-specific ARARs.

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
FEDERAL ARARS – ACTION SPECIFIC				
Fish & Wildlife Coordination Act	33 CFR 320-330 40 CFR 6.302(h) 50 CFR 83	R	Requires coordination with federal and state agencies for activities that have a negative impact on wildlife and/or non-game fish.	If the removal action involves activities that affect wildlife and/or non-game fish, conservation of habitats must be undertaken.
Clean Air Act	40 CFR Part 61, Subpart M (delegated to the state and incorporated by reference at ARM 17.8.341)	See below for specific regulations.	NESHAPs for Asbestos	
Clean Air Act	40 CFR 61.145(c) & (d)	R	Standard for Demolition and Renovation. Provides detailed procedures for controlling asbestos releases during demolition of a building containing a regulated asbestos containing material (RACM) as defined in the regulations.	The dust control portions of the regulations are relevant and appropriate for soil disturbance activities and for asbestos contaminated material that does not meet the strict definition of RACM.
Clean Air Act	40 CFR 61.149 Note: Section 61.149(c)(2) is not delegated to the State	R	Standard for Waste Disposal at Asbestos Mills. Provides detailed procedures for handling and disposal of asbestos containing waste material generated by an asbestos mill as defined by 40 CFR 61.142.	This regulation is considered relevant and appropriate to soil disposal. It is not applicable because the facilities do not meet the regulatory definition of an asbestos mill.

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
Clean Air Act	40 CFR 61.150 Note: Section 61.150(a)(4) is not delegated to the State.	R	Standard for waste disposal for manufacturing, fabricating, demolition, renovation and spraying operations. Similar to 40 CFR 61.149, this section provides detailed procedures for processing, handling and transporting asbestos containing waste material generated during building demolition and renovation (among other sources).	Relevant and appropriate for soil disturbance activities and for asbestos contaminated material that does not meet the strict definition of RACM.
Clean Air Act	40 CFR 61.151 Note: Section 61.151(c) is not delegated to the State.	R	Standard for inactive waste disposal sites for asbestos mills and manufacturing and fabricating operations. Provides requirements for covering, revegetation and signage at facilities where RACM will be left in place.	These requirements would be relevant and appropriate to asbestos containing soils and debris left in place.
National Historic Preservation Act (NHPA)	36 CFR 800 40 CFR 6.301 (b) 43 CFR 7	A	Establishes procedures to take into account the effect of actions on any historical properties included on or eligible for inclusion on the National Register of Historic Places. If the activity will have an adverse effect, and this effect can not be reasonably avoided, measures need to be taken to minimize or mitigate the effects.	If cultural resources on or eligible for the National Register are present, it will be necessary to determine if there will be an adverse effect, and if so, how the effect may be minimized or mitigated.

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
Archeological Resources Protection Act	16 USC 470aa-47011 43 CFR Part 7	A	Prohibits the unauthorized disturbance of archaeological resources on public and Indian lands. Archaeological resources are "any material remains of past human life and activities which are of archaeological interest," including pottery, baskets, tools, and human skeletal remains. The unauthorized removal of archaeological resources from public or Indian lands is prohibited without a permit, and any archaeological investigations at a site must be conducted by a professional archaeologist. ARPA and implementing regulations are applicable for the conduct of any investigatory or remedial actions that may result in ground disturbance.	
Native American Graves Protection and Repatriation Act	25 U.S.C. 3001, et seq.	R	Protects Native American graves from desecration through the removal and trafficking of human remains and "cultural items" including funerary and sacred objects. To protect Native American burials and cultural items, the regulations require that if such items are inadvertently discovered during excavation, the excavation must cease and the affiliated tribes must be notified and consulted. This program is applicable to ground-disturbing activities such as soil trenching, grading, and removal.	

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
Occupational Safety and Health Act	29 CFR 1926.1101	R	Regulates asbestos exposure in all work including removal or encapsulation of materials containing asbestos. Specifies requirements for permissible exposure limits (PELs), monitoring, and training.	Requires that the PEL for workers exposed to asbestos be no higher then 0.1 fibers per cubic centimeter, averaged over an 8-hour day.
Migratory Bird Treaty Act (MBTA)	16 USC. 703 et seq. 50 CFR 10.13	R	Makes it unlawful to "hunt, take, capture, kill" or take other actions adversely affecting a broad range of migratory birds without prior approval by the U.S. Fish and Wildlife Service. Under the MBTA, permit may be issued for take (e.g., research) or killing of migratory birds (e.g., hunting licenses). The MBTA and implementing regulations are relevant and appropriate for protecting migratory bird species identified within the area of the site. The site investigation and remedial actions will be carried out in a manner that avoids the taking or killing of protected bird species, including individual birds or their nests or eggs.	Within the Ponderosa pine habitat of the site, migratory bird species protected by the MBTA may likely include songbirds, woodpeckers, owls, and hawks.
Endangered Species Act	16 USC. 1531 et seq. 50 CFR 10, 13,17, 402	A	Makes it unlawful to "harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any federally-designated threatened or endangered species. The ESA and implementing regulations are applicable to activities that could affect federally-designated species that may be discovered within the site.	There has been no verified presence of endangered species on site, but there are several endangered species that occur in Klamath County (see Section 2.3.8.3).

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
State ARARs				
DEQ- Asbestos Requirements	Oregon Administrative Rule (OAR) 340-248	A	Requires notification to DEQ prior to asbestos abatement and requires that non-friable asbestos be handled and disposed in a method that will prevent the release of airborne asbestos.	Certain removal methods may turn non-friable asbestos to friable asbestos. In this instance, regulations for handling and disposal become much more restrictive.
Oregon Air Pollution Control Law	Oregon Revised Statutes (ORS) 468A. 700 to 760	R	Provides licensing requirements for workers on asbestos abatement projects.	
Oregon Hazardous Waste Management Act	ORS 466 OAR 340-100	A	Provides requirements that must be met for the generation, transportation, treatment, storage, and disposal of hazardous wastes.	ACM is not classified as hazardous material, but this could be applicable to other COCs (if there is surface water at the site).
Oregon OSHA Regulations	OAR 437-003-0001	A	Requires that regulations given in 29 CFR 1926.1101 be met.	Oregon has adopted the federal OSHA requirements for working with ACM.
Solid Waste Management	ORS 459 OAR 340-093, 340-094, 340-095	R	Provides requirements for the management and disposal of solid waste, including on-site and off-site disposal.	If on-site disposal is selected as the remedial action, the disposal site will have to be approved and permitted through DEQ; otherwise, material will have to be disposed of in a landfill permitted to accept ACM.
Oregon Environmental Cleanup	ORS 465.200-900 OAR 340-122-010 through -140 OAR 340-122-0510 through -0590	A	Outlines the process to be used to address toxic substances in the environment; summarizes liability schemes; provides basis for selection of a remedy.	

Table 10-1. Summary of ARARs

Statute	Implementing Regulation	Status	Requirements	Comments
Oregon Wildlife Management Plan	OAR 635-100	R	Requirements may be location-specific if threatened or endangered species are determined to be affected adversely by site cleanup activities.	There has been no verified presence of endangered species on site, but there are several endangered species that occur in Klamath County (see Section 2.3.8.3).
Local ARARs				
Klamath County Code -Solid Waste Management	400.200	R	Requires approval from the Klamath County Board of Commissioners prior to establishment of a new disposal site.	If on-site disposal is selected as the remedial action, the disposal site will have to be approved by the Klamath County Board of Commissioners.

A = Applicable; N = Scope of the action does not trigger this requirement; R = Relevant & Appropriate.

11. SCHEDULE

A schedule for the overall RI/FS project is shown below.

The project will proceed through a basic series of steps: overall work planning, site investigation, evaluation of investigation results, additional investigation (if needed), assessment of risk, and development and evaluation of alternatives. Key documents and general timeframes in the process are identified in the schedule and include the following:

- An RI/FS work plan (this document) will be released in April 2006.
- Site reconnaissance will be completed in late spring, once snow has melted and bare ground and remnant building foundations are visible. Following the reconnaissance, the SAPs will be completed for summer 2006 site investigations.
- Preliminary presumptive remedial alternatives will be developed during the RI/FS work plan development and continually updated and evaluated as the RI proceeds.
- A site investigation will be conducted in early summer 2006. That investigation will include additional inspection of the site to determine and resolve areas and sites for binning, investigation of large land units, activity-based sampling, and investigations for non-asbestos COPCs.
- Analytical results from the site investigation will be evaluated in the summer and fall of 2006. If additional investigations are needed to fill remaining data gaps, they will be performed in the fall of 2006.
- The baseline risk assessment and RI report will be prepared in the winter of 2006-2007.
- Final remedial alternatives development and evaluation will occur in the late fall of 2006 through the winter of 2007, and the FS report will be completed in early Summer 2007.
- The Proposed Plan, which outlines EPA's preferred remedy for the site, will be released for formal public comment in mid-summer 2007.
- After considering public comments on the Proposed Plan, EPA will prepare a ROD for the site which represents the final decision document for the site. The ROD will contain a Responsiveness Summary that records the public comments received and explains how those comments were considered. The ROD is expected to be signed by late September 2007.

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APPENDIX A

Calculation of Risk-Based Concentrations

1.0 INTRODUCTION

Asbestos is the primary COC in soil at the North Ridge Estates (NRE) site near Klamath Falls, Oregon. The purpose of this Appendix is to provide screening level equations that predict the level of human health risk that may be associated with some specified level of asbestos in soil. These calculations can then be used to calculate the level of asbestos that would be associated with some specified maximum acceptable level of risk. Such values are usually referred to as risk-based concentrations (RBCs). RBCs are often used by risk managers in planning site investigations and in evaluating remedial strategies.

2.0 EXPOSURE PATHWAYS OF CONCERN

When asbestos is present in soil, there are several pathways that may lead to inhalation exposure by humans, including:

- Asbestos may be released into the personal breathing zone of an individual who is engaged in some activity that disturbs the soil (e.g., digging, raking, weed-trimming, etc.).
- Contaminated soil may be transferred on shoes or clothing or by air into indoor dust in indoor living spaces. Disturbance of the indoor dust by normal indoor activities can re-suspend the asbestos into indoor air.
- Asbestos may be released from the soil into ambient outdoor air by wind or mechanical forces that disturb the soil.

The following sections present the equations needed to quantify human exposure from each of these pathways.

3.0 QUANTIFICATION OF EXPOSURE

3.1 Estimation of Airborne Asbestos Levels

Asbestos in Personal Air During Active Disturbances

The concentration of asbestos in personal air during activities that actively disturb soil may be estimated using an equation of the following form:

$$C(\text{personal air}) = C(\text{soil})\ PEF_{scenario}$$

where:

$PEF_{scenario}$ = Scenario-specific particulate emission factor (g soil per cc of air, g/cc)

The value of $PEF_{scenario}$ is expected to vary substantially as a function of the type, intensity and duration of various disturbance scenarios, and also as a function of the soil conditions (wet *vs.* dry, grass covered *vs.* bare, etc.). Thus, it is difficult to select any single value for $PEF_{scenario}$ that is likely to be appropriate in all cases. For the purposes of this evaluation, a screening level value of 5E-09 g/cc was selected. This value is similar to values predicted by screening-level release and dispersion models (Berman 2004) and to measured values of dust observed during soil disturbance activities at this site (3E-09 to 6E-09 g/cc) and at other sites (up to 2E-08 g/cc). This level corresponds to an airborne particulate level of 5000 ug/m^3.

Asbestos in Indoor Dust and Indoor Air

The transfer of asbestos from outdoor soil to indoor dust may be modeled using the following equation:

$$C(dust) = C(soil)\ Ksd$$

where:

C(dust) = Concentration of asbestos in indoor dust (s/g dust)

Ksd = Transfer factor for soil to dust (g soil per gram of dust)

Given the concentration of asbestos in indoor dust, the concentration in indoor air is calculated as:

$$C(indoor\ air) = C(dust) \cdot PEF_{indoor}$$

where:

PEF_{indoor} = Transfer factor for dust into indoor air (g dust per cc of air, g/cc)

Combining these two equations yields:

$$C(indoor\ air) = C(soil) \cdot Ksd \cdot PEF_{indoor}$$

EPA typically assumes a value for Ksd of about 0.7 to 1.0 (i.e., 70-100% of the dust that occurs indoors is derived from soil). However, studies at a number of Superfund sites have suggested that this value is likely to be somewhat too high in most cases, so a value of 0.3 (30%) was assumed for this evaluation.

Data on dust levels that may occur in indoor air under conditions of routine human occupancy are limited, but values of 3E-12 to 2E-10 g/cc (average = 3E-11 g/cc) have been observed at other sites, and similar values have been reported in the literature (e.g., Levy et al. 2000). For the purposes of this screening assessment, a PEF_{indoor} value of 5E-11 g/cc was assumed. This corresponds to an airborne level of 50 ug/m^3.

Ambient Air

The transfer of asbestos from soil to ambient air may be evaluated using the following equation:

$$C(ambient\ air) = C(soil) \cdot PEF_{ambient}$$

where:

C(ambient air) = Concentration of asbestos in ambient air (structures per cubic centimeter, s/cc)

C(soil) = Concentration of asbestos in soil (structures per gram, s/g)

$PEF_{ambient}$ = Particulate emission factor for ambient air (g soil per cc of air, g/cc)

The USEPA recommends a default value for $PEF_{ambient}$ of 1E-12 g/cc (USEPA 2002). This corresponds to a suspended dust level of 1 ug/m^3.

3.2 *Human Exposure Parameters*

All available models for predicting excess cancer risk from inhalation exposure to asbestos (see Section 4.0, below) are based on the long-term (lifetime) average concentration of asbestos in air. Thus, if exposures occur that are not continuous over the lifetime, it is necessary to compute a time-weighted average (TWA) concentration in air that would yield the same inhaled dose if the exposure were for a lifetime; this is calculated as follows:

$$C(air)_{TWA} = C(air) \cdot \text{TWA Factor}$$

For a resident, the following values of ET and ED were used:

Scenario	TWA Factor
Ambient air	0.0625
Active disturbance of soil	0.010
Indoor exposures	0.928

The TWA factor for exposure to ambient air is based on USEPA's Exposure Factors Handbook (USEPA 1997), which indicates that most people spend about 1.5 hrs/day outside. Based on this, the TWA factor is:

$$TWA(\text{ambient air}) = 1.5/24 = 0.0625$$

The TWA factor for active disturbance of soil is based on the assumption that this type of activity might occur for 4 hours per day, 50 days per year, and for 30 years out of a lifetime:

$$TWA(\text{active disturbance}) = 4/24 \cdot 50/365 \cdot 30/70 = 0.010$$

The TWA for indoor exposures is calculated by difference.

4.0 QUANTIFICATION OF RISK

Standard Risk Model (IRIS)

The USEPA has developed a quantitative model for predicting the lifetime excess risk of cancer (lung cancer plus mesothelioma) in an individual exposed to asbestos. This model, which is described on EPA's IRIS website, may be written as:

$$\text{Risk} = C(\text{air})_{TWA} \cdot \text{Unit Risk}$$

where:

Risk = probability that an individual will die from a site-related asbestos exposure

Unit risk = Risk per unit concentration of asbestos in air (s/cc)

In this model, the concentration of asbestos in air is expressed in units of s/cc that are measured using phase contrast microscopy (PCM). A fiber is counted under PCM if it meets the following size requirements:

Length > 5 um

Width $\geq$ 0.25 um (the resolving power of a PCM scope)

Aspect ratio $\geq$ 3:1

When concentration is expressed using PCM as the measurement technique, the lifetime average unit risk is 0.23 per PCM s/cc (IRIS 2006).

Alternative Risk Models

One potential limitation to the current standard risk model is that it does not distinguish between the two main mineralogical forms of asbestos (chrysotile and amphibole). However, data have accumulated that suggest that amphibole asbestos (including amosite) is more potent in causing cancer than chrysotile asbestos (USEPA 2003; Hodgeson and Darnton 2000). None of these alternative models have been reviewed or approved for use by EPA so it is not possible to use them for quantitative calculations. However, it is important to bear in mind that calculations of RBC values presented below based on the IRIS model may tend to underestimate the risks due to exposures to amphiboles (e.g., amosite in MAG).

5.0 CALCULATION OF RISK-BASED CONCENTRATIONS

5.1 Target Risk

The level of risk that is acceptable from an environmental contaminant is a matter of judgment. The USEPA typically considers a risk of 1E-04 to be the highest that can be tolerated without triggering the need for remedial action (USEPA 1991). The State of Oregon has established a regulatory requirement that sets a target risk level of 1E-06 (Oregon 2006). For the purposes of this assessment, results are presented for target risk values of 1E-04, 1E-05 and 1E-06.

5.2 RBC For Asbestos Fibers in Soil

Based on the exposure equations given above, the RBC for asbestos fibers in soil may be calculated as:

$$RBC(s/g) = \frac{Target\ Risk}{(PEF_{ambient} \cdot TWA_{ambient} + PEF_{scenario} \cdot TWA_{scenario} + Ksd \cdot PEF_{indoor} \cdot TWA_{indoor}) \cdot Unit\ Risk}$$

Results based on the input values selected above are shown below:

Target Risk Level	RBC (PCM s/g soil)
1E-04	6.9E+06
1E-05	6.9E+05
1E-06	6.9E+04

5.3 RBC for ACM in Soil

The relationship between the amount of ACM in soil and the amount of fibers that might be released into soil in the future if all the ACM were to migrate to the surface and be entirely broken down is as follows:

$$Csoil\ (s/g) = \frac{ACM\ (g\ ACM/cm^2) \cdot SPG\ (PCM\ s/g\ ACM)}{MD\ (cm) \cdot SD\ (g\ soil/cm^3\ soil)}$$

where:

ACM = Amount of ACM per unit area (g ACM/cm^2 of soil, summed across all depths)

SPG = PCM structures per gram ACM

MD = Mixing depth (depth to which asbestos fibers in surface soil will mix) (cm)

SD = Soil density (grams of soil per cm^3 of soil)

Data on the value of SPG are available from PCM analysis of pieces of ACM obtained at the site (E&E 2006). Values are summarized below:

ACM Type	PCM s/g ACM
CAB	3.0E+08
Air Cell	1.6E+09
Roofing tiles	1.7E+09
Floor tiles	1.4E+08
MAG	1.1E+09

Based on these estimates of SPG, and assuming a mixing depth of 1 inch (2.54 cm) and a bulk soil density of 1.5 g/cm^3, the resulting IRIS-based RBCs for ACM are as follows:

Target Risk Level	RBC (g ACM /cm^2 soil)				
	CAB	AirCell	Roofing	Floor Tile	MAG
1E-04	8.8E-02	1.6E-02	1.5E-02	1.9E-01	2.4E-02
1E-05	8.8E-03	1.6E-03	1.5E-03	1.9E-02	2.4E-03
1E-06	8.8E-04	1.6E-04	1.5E-04	1.9E-03	2.4E-04

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APPENDIX B

Borehole Calculations

1.0 INTRODUCTION

Asbestos is the primary COC in soil at the North Ridge Estates (NRE) site near Klamath Falls, Oregon. In particular, concern exists over the occurrence of ACM in subsurface soil, since this is a continuing source that cannot be observed directly. There are five main types of ACM observed at the NRE site: concrete asbestos board (CAB), vinyl asbestos tiles (VAT), roofing materials, and two types of pipe wrap – AirCell and MAG. Quantification of the amount of buried ACM is a difficult task, since it does not exist in a continuous deposit, but occurs in discrete pieces of varying type, size, and thickness in random locations. One approach for estimating the amount of ACM present in an exposure unit is to place a number of boreholes into the subsurface soil and measure the total amount of ACM present in each boring, combined across all depths from the surface to the base of the boring. The results for each borehole would be expressed in units of grams of ACM per unit surface area sampled (e.g., grams ACM per cm^2), which may then be evaluated by comparison to the appropriate risk-based concentration (RBC) for ACM is soil (see Appendix A).

The purpose of this appendix is to provide screening level calculations of the number of boreholes that would be needed in a decision unit (exposure area) in order to detect ACM with confidence if it were present at the RBC.

2.0 LEVELS OF CONCERN

Appendix A provides calculations of the RBCs of ACM in soil, expressed in units of g ACM / cm^2 of soil. The results are summarized below:

Target Risk Level	RBC (g ACM /cm^2 soil)				
	CAB	AirCell	Roofing	Floor Tile	MAG
1E-04	8.8E-02	1.6E-02	1.5E-02	1.9E-01	2.4E-02
1E-05	8.8E-03	1.6E-03	1.5E-03	1.9E-02	2.4E-03
1E-06	8.8E-04	1.6E-04	1.5E-04	1.9E-03	2.4E-04

For the purposes of this evaluation, all calculations are based on a target risk of 1E-04. Results for any other target risk level can be derived by simple linear extrapolation. For example, if N boreholes are needed to evaluate an area based on a 1E-04 risk level, then 10xN boreholes would be needed to evaluate an area based on a 1E-05 risk level, and 100xN would be needed to evaluate an area based on a 1E-06 risk level.

3.0 TENTATIVE DECISION RULE

Conceptually, all that is needed to make a decision about the acceptability of an exposure area is an estimate of the mean amount of ACM present in the area (g ACM/cm^2), followed by a comparison of that value to the RBC. However, because of sampling and analytical variability, the data collected from the exposure area might lead to either underestimates or overestimates of the true amount of ACM present. Two types of decision error are possible:

- *False Negative.* In this case, the true concentration of ACM in the decision unit is above the RBC, but the measured value is below the RBC.
- *False Positive.* In this case, the true concentration of ACM in the decision unit is below the RBC, but the measured value is above the RBC.

Controlling False Negative Errors

In most cases, false negative errors are of greatest concern to EPA, since a false negative decision may lead to exposure of humans to unacceptable risks. Therefore, EPA generally sets a goal that the probability of making a false negative decision is no higher than 5%. This is usually accomplished by computing the 95% upper confidence limit (UCL) on the mean, and comparing that value (rather than the simple mean) to the RBC. If the 95% UCL does not exceed the RBC, then there is no more than a 5% chance of a false negative decision error occurring.

Based on this, the tentative decision rule at this site is:

If the 95% UCL of the mean level of ACM in an exposure unit does not exceed the RBC, the exposure unit will be considered acceptable. If the 95% UCL of the mean exceeds the RBC, the exposure unit will be considered potentially unacceptable.

Controlling False Positive Errors

While the use of the 95% UCL for decision making automatically ensures a high degree of protectiveness, application of this approach tends to increase the occurrence of false positive decision errors. For example, a property for which it is 90% certain (rather than 95% certain) that the risk is acceptable would be declared unacceptable. A false positive decision error does not pose a risk to residents, but can result in substantial expenditure of resources (both time and money) on properties that are actually acceptable. In order to address this problem, the number of samples collected at a decision unit is usually chosen to limit the probability of a false positive decision to some specified criterion. At this site, that criterion is that there should be no more than a 20% chance of declaring an exposure unit unacceptable when the true concentration is ½ the RBC.

4.0 METHOD FOR COMPUTING THE 95% UCL

The method used to compute the 95% UCL of the mean of a set of measured values depends on the nature of the data set. If the data are well characterized by a normal or lognormal distribution, then standard equations are available for computing the UCL (USEPA 1992). However, in many cases, data sets are not well characterized by parametric distributions, and other approaches may be more appropriate. EPA has developed a software system called ProUCL (USEPA 2004) that computes alternative estimates of the UCL for a data set by a variety of different strategies, and recommends the value that is most appropriate based on the nature of the data provided.

At this site, data are not available to estimate the nature of the data that might be generated by a borehole investigation. For this reason, computer-based simulations were performed to generate a series of hypothetical data sets that might be reasonable expectations of the nature of real data sets, and these were provided to ProUCL to determine which statistical procedure was recommended as most appropriate. In nearly all cases, the ProUCL software selected the Chebychev inequality method for computing the UCL. This procedure is as follows:

- $\text{UCL} \leq \text{Mean} + (1/\alpha - 1)^{0.5} \cdot \text{stdev}/N^{0.5}$

For $\alpha = 0.05$, this yields

- $\text{UCL} \leq \text{Mean} + 4.36 \cdot \text{stdev}/N^{0.5}$

5.0 ESTIMATING THE NUMBER OF BOREHOLES NEEDED TO LIMIT DECISION ERRORS

5.1 Number Needed to Avoid False Negative Decisions

In considering the number of boreholes that must be installed, the first step is to identify the minimum number required to provide sufficient power to detect ACM contamination if it were present at a level of concern. For this effort, the minimum number of boreholes required is defined as the number such that there is at least a 95% probability that one or more boreholes will intercept the ACM when it is present at a level of concern. This is important because, if every borehole is negative (non-detect), the mean is zero and the 95% UCL (computed as above) is also zero. Thus, if the true concentration were above the RBC, this would rank as a false negative decision.

In order to compute this minimum number of boreholes, it is first necessary to convert the RBC values presented above (expressed in units of g ACM/cm^2) into units of area fraction (cm^2 of ACM per cm^2 of soil surface). For convenience, the result may be referred to as the area fraction of concern (AFOC). This conversion is performed as follows:

$$\text{AFOC (cm}^2\text{ ACM/cm}^2\text{ soil)} = \text{RBC (g ACM/cm}^2\text{ soil)} / [T_{ACM}\text{ (cm)} \cdot D_{ACM}\text{ (g/cm}^3\text{)}]$$

where:

T_{ACM} = Average thickness of a piece of ACM (cm)

D_{ACM} = Average density of a piece of ACM (g / cm^3)

Values for T_{ACM} and D_{ACM} are available from measurements performed on pieces of ACM collected at the site (E&E 2006), as summarized below:

Parameter	CAB	AirCell	Roofing	Floor Tile	MAG
T_{ACM} (cm)	0.45	0.25	0.30	0.30	0.60
D_{ACM} (g / cm^3)	1.93	2.88	1.14	1.52	1.28

Based on these data, the corresponding area fractions of concern are as follows:

Target Risk Level	Area Fraction of Concern (cm^2 ACM /cm^2 soil)				
	CAB	AirCell	Roofing	Floor Tile	MAG
1E-04	0.101	0.023	0.045	0.412	0.031

In order to estimate the minimum number of boreholes needed to have at least one detect if the true concentration exceeds the RBC, it is assumed that the probability of a detect is proportional to the AFOC occupied by the ACM. For example, if the AFOC were 0.05 (5%), then there is only a 5% chance that a random borehole would detect the ACM, and a 95% chance the borehole would be non-detect. If more than 1 borehole is installed, the probability that all of the boreholes will be non-detect is given by:

$$\text{Probability(All ND)} = (1\text{-AFOC})^N$$

The following table shows the minimum number of boreholes required to ensure there is a 95% chance of at least one detect occurring in an exposure area investigation, based on a 1E-04 risk level:

Area Fraction of Concern	Minimum Number of Boreholes
0.2%	1497
0.5%	598
1.0%	299
2.0%	149
3.0%	99
5.0%	59
10%	29
15%	19

As noted above, based on EPA's IRIS risk model, the ACM type with the smallest AFOC is AirCell (2.3% at a target risk of 1E-04), and the minimum number of samples required for this AFOC is 129. If a risk level of 1E-05 or lower were selected, the AFOC would be 0.23% or lower, and the minimum number of boreholes per decision unit would be 1290 or more.

5.2 Number Needed to Limit False Positive Decisions

Use of the minimum number of boreholes is expected to minimize the chance of a false negative decision error; however, if only the minimum number of boreholes are installed, the risk of false positive decisions may be quite high. In order to investigate the relationship between the number of boreholes and the false positive error rate, a screening level assessment was performed using Monte Carlo modeling.

In this approach, Monte Carlo simulation is used to place random boreholes in an exposure unit where the true average area fraction of ACM for the exposure unit is specified. The concentration of ACM in each borehole is given by:

$$C(i) = P \cdot A_{ACM} \cdot T_{ACM} \cdot D_{ACM} / A_{Borehole}$$

where:

$C(i)$ = Concentration of ACM in borehole "i" (g / cm^2)

P = Probability that the borehole will intercept a piece of ACM

A_{ACM} = Area of ACM intersected in the borehole (cm^2)

T_{ACM} = Thickness of the ACM (cm)

D_{ACM} = Density of the ACM (g / cm^3)

$A_{borehole}$ = Area of the borehole (cm^2)

For convenience, assume the area of the ACM in a borehole is the same as the area of the borehole. Then:

$$C(i)\ (g/cm^2) = P \cdot T_{ACM} \cdot D_{ACM}$$

The probability of a detect is modeled as:

P = BINOMIAL(true area fraction for the exposure unit)

Thickness may be modeled as:

T_{ACM} = Average thickness Triangular(0.5, 1, 2)

Density is assumed to be constant.

Values of thickness and density are based on measurements form site samples, and are provided above.

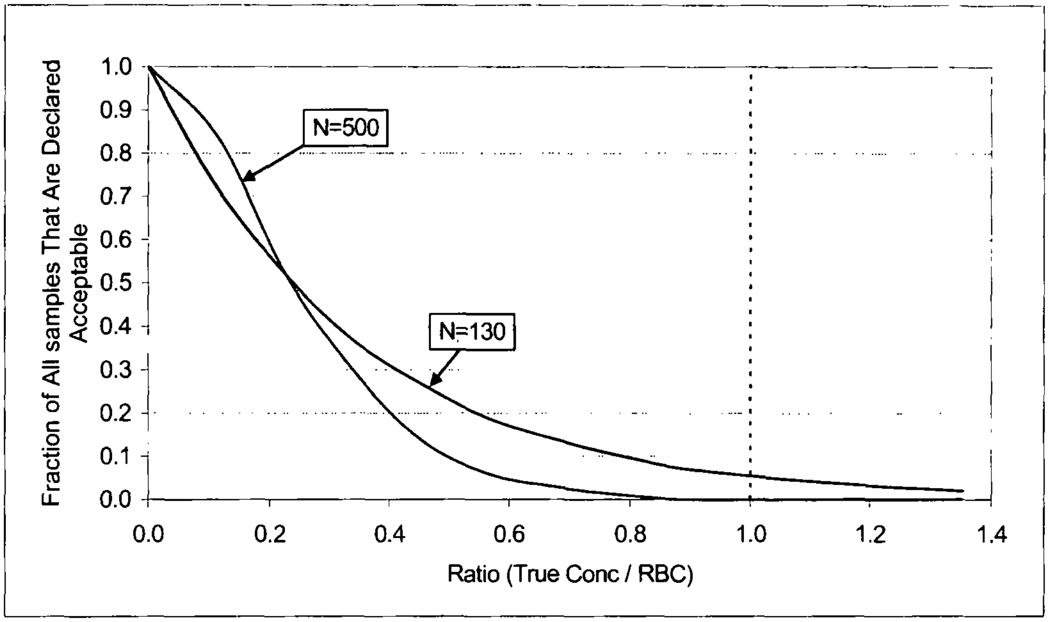
Given a set of random boreholes placed in an exposure unit with some specified true area fraction, each borehole will yield a random value of C(i). From this data set, the mean and standard deviation can be used to compute the 95% UCL, assuming the Chebychev inequality approach (see Section 4.0, above). Then, the UCL is compared to the RBC, and the sample is ranked either as "Pass" (UCL ≤ RBC) or "Fail" (UCL > RBC).

The results are shown in Figure B-1. As seen, the probability of "failing" (declaring the area is unacceptable) is very high (> 75%), even when the true concentration of ACM is ½ or less of the RBC, even if a very large number of boreholes (500 per decision unit) were installed. This pattern does not depend on the type of ACM present, but is true for all types and combinations.

6.0 CONCLUSIONS

Based on the RBC levels for ACM derived in Appendix A using EPA's standard risk model (IRIS) and assuming a target risk level of 1E-04, it is concluded that a large number of boreholes (a minimum of 130) would be needed in each decision unit in order to guard against false negative decision errors, and that a much higher number (>> 500) would be needed in order to limit the frequency of false positive decision errors. If a lower target risk level were selected (1E-05, 1E-06), the number of boreholes needed would be proportionately higher. Based on these calculations, it is concluded that unless very large numbers of boreholes are installed in each decision unit, application of the approach above would have low probability of declaring that a decision unit was acceptable, even in situations where it really was acceptable.

Figure B-1. Simulated Sampling Results for an Area Contaminated with ACM



7.0 REFERENCES

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